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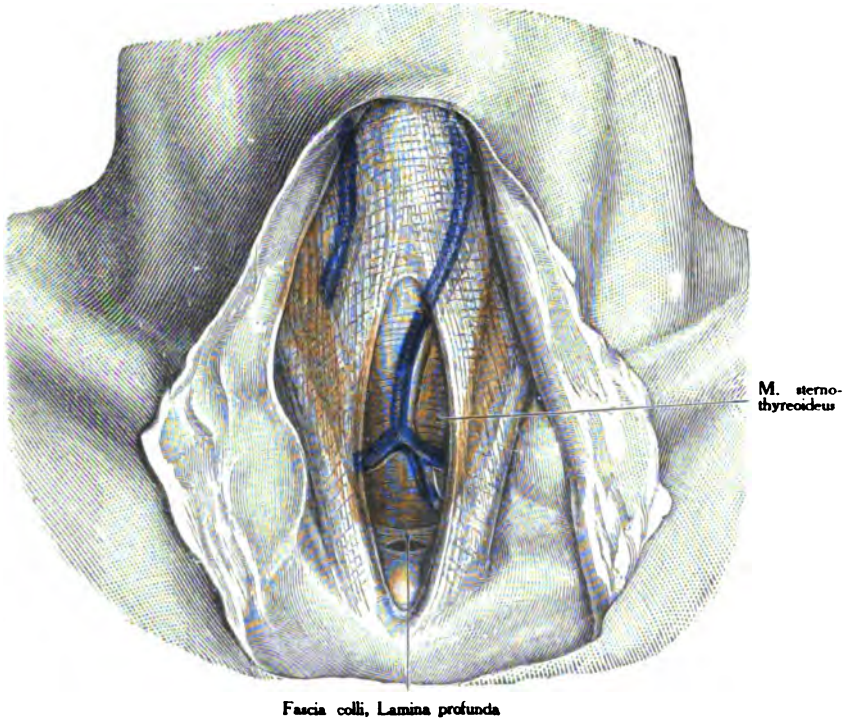

Suprasternal Space (Zuckerkandl Atlas).

NASAL SINUS SURGERY

WITH

OPERATIONS ON NOSE AND THROAT

BY

BEAMAN DOUGLASS, M.D.

PROFESSOR OF DISEASES OF THE NOSE AND THROAT IN THE NEW YORK POST-GRADUATE MEDICAL SCHOOL AND HOSPITAL

Illustrated with 67 Full-Page Half-tone and Colored Plates, Including nearly 100 Figures

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THIS BOOK IS DEDICATED TO MY
FATHER AND MOTHER

PREFACE.

THIS little work on Nasal Sinus Surgery, with Operations on Nose and Throat, has been written because of demands made for such a work by physicians who have worked under my direction. Perhaps it will be useful to others. The author desires to acknowledge his indebtedness to Dr. Charles Graef for assistance in proof-reading.

BEAMAN DOUGLASS.

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Nasal Sinus Surgery, with Operations on Nose and Throat.

CHAPTER I.

GENERAL ANATOMICAL REVIEW OF THE NOSE.

The External Nose.

The human nose is divisible into an internal and an external part, called respectively the internal naris and the external naris. The nose is open in front for the introduction of air by means of two holes which are on the under soft part of the nose, while behind it is continuous with the cavity known as the naso-pharynx, by means of two openings known as the choanæ. The external nose consists in its upper part of bone, which is formed by the nasal bones and forms the bridge of the nose. The lower part of the nose is formed of soft tissue and cartilage. These parts are covered with skin and other soft structures which do not concern us as rhinologists.

NASAL ORIFICES.

The under surface of the soft part of the nose contains two openings known as the orifices of the nose. These orifices are bounded on the median side by the triangular cartilage of the nasal septum, and externally by the cartilage of the ala nasi. These openings vary in different individuals, but extend from the median line somewhat outward, and backward, and downward.

VESTIBULE.

Just beyond the orifice of the nose is the vestibule. This consists of a pyramidal cavity wider behind than in front. It

is bounded on the median side by the nasal septum, and on the outer side by the soft tissues of the nose. It extends from the nasal orifice in front to a perpendicular line behind, which touches the anterior end of the inferior turbinate body. The vestibule of the nose is therefore mostly within the soft tissue structure, but about one-quarter of an inch of it extends within the space bounded by the nasal bones. The posterior margin of the vestibule of the nose corresponds to a line dropped perpendicularly from the fronto-nasal suture, through the anterior end of the inferior turbinate body. The vestibule of the nose is lined with mucous membrane, continuous with the skin in front and with the mucous membrane of the internal nose behind.

In front the epithelium is squamous, which gradually changes until at the posterior part of the vestibule it becomes ciliated. The whole of the remainder of the nasal space, including each meatus and all of the accessory sinuses, is lined with ciliated epithelium. As rhinologists, it is the internal part of the nose which interests us most.

The Internal Nose.

BOUNDARY AND GENERAL TOPOGRAPHY.

The internal nose on each side consists of a large space which lies above the palatal processes of the superior maxillary bone and below the plate of bone for the reception of the anterior lobe of the brain. It is bounded in the median line by the nasal septum, and externally by the external nasal wall. In front, it is continuous with the vestibule of the nose, and begins at the perpendicular line running from the base of the nasal bone through the anterior end of the inferior turbinate body. Behind, it is separated from the naso-pharynx by an imaginary line running through the extreme posterior ends of the inferior and middle turbinate bodies.

The space of the internal nose is very much narrowed by

Fig. 1.—Section Showing Left Side of the Nose. The turbinal bodies—inferior and middle—are well shown. The inferior has some cautery marks on its surface. Above the middle is the nasal wall of the posterior ethmoid cells, usually called the superior turbinal body. A small sphenoidal cavity is seen back of this in the body of the sphenoid bone, and above this, a much larger space is a large posterior ethmoid cell. The middle turbinal hides important structures in this wall—the bulla ethmoidalis, the hiatus semilunaris and the processus uncinatus. Back of the superior turbinal is seen the opening of the Eustachian tube.

the presence of the ethmoid cells. The outer wall of the internal nose is very irregular, but extends obliquely downward and outward, so that its base is farther from the median line below than at the roof. The roof of the internal nose is not more than one-eighth of an inch wide, while the floor is about one inch wide.

(NOTE.—It must be remembered, in the descriptions which are given here in which measurements are noted, that when only one measurement is given it is to be considered an average measurement.)

The septal wall of the internal nose is perpendicular. In front, it is cartilaginous, but behind it is entirely bony. It is covered with mucous membrane. The entire roof of the nose is a part of the superior meatus, and is about one-eighth of an inch in width. It is perforated with numerous foramina for the conduction of the olfactory vessels and nerves.

THE FLOOR.

The floor of the internal nose is slightly wider behind than in front, and slants downward from its anterior part, so that the level of the floor of the nose in front is one-quarter of an inch higher than behind. The floor of the nose is concave laterally, and the entire floor is part of the inferior meatus.

THE EXTERNAL WALL.

The external wall of the nose is the most interesting one for study. It is the wall that lies nearest the eye and cheek. This wall bears two large bodies known as the turbinate bodies, which project from its surface downward and toward the nasal septum in such a way that the internal nose is divided into three smaller cavities, known as the inferior meatus, the middle meatus, and the superior meatus.

(*a*) The inferior turbinate body springs from about the middle of the external wall of the nose, and extending downward

and inward presents two surfaces, the lower of which lies in the inferior and the upper in the middle meatus.

(*b*) The middle turbinate body extends more perpendicularly downward from the lateral wall than does the inferior turbinate. It is a part of the ethmoid bone and is attached to the external wall near its upper third, at about the level of the inner canthus of the eye. Its external surface is a part of the middle meatus, while its internal surface belongs to the superior meatus.

DESCRIPTION OF THE NASAL MEATUSES.

THE INFERIOR MEATUS—*Boundaries:*—The inferior meatus of the nose occupies the lower part of the nasal space. It is not as large as the middle meatus, and is limited on the median side by the nasal septum; below, by the floor of the nose; externally, by the external nasal wall; and above, by the under or external surface of the inferior turbinate body, and by a line drawn from the lower border of the inferior turbinate body across the nasal space to the septum. The inferior meatus therefore extends higher up upon the external nasal wall than it does upon the septal wall, and includes the large fossa, bounded by the external nasal wall and the under surface of the inferior turbinate body.

Opening of Lacrymal Duct.—The external wall of the inferior meatus is opposite the lower half of the antrum. If the inferior turbinate body is cut in such a way that it may be lifted from its attachments and carried upward, there will be seen in the inferior meatus, on the external nasal wall at its highest point, a small opening into which a probe will pass to the lacrymal duct. This opening is generally half an inch behind the anterior end of the inferior turbinate body, and is directly at the angle of the junction of the external nasal wall and the inferior turbinate body.

Antrum Perforation.—About half an inch behind the opening of the lacrymal duct and on the same level, there is a thin

Fig. 2.—Cross Section of Nose at Anterior End of Middle Turbinate Bodies. 1, Middle turbinate body. 2, Inferior turbinate body. 3, Ethmoid cells. 4, Nasal septum. 5, Orbit. 6, Inferior meatus. 7, Middle meatus. 8, Superior meatus. 9, Part of maxillary antrum.

plate of bone which can be best seen in the bony skull. It is a part of the inferior turbinate body, and closes up part of the heart-shaped opening leading into the antrum, which is seen in skeletal preparations. (See description of "Internal Antral Wall.") This thin plate of bone is the thinnest part of the nasal and antral wall, and is known as the antral process of the inferior turbinate body. It is the place which one selects for the puncture of the antrum for diagnosis of suspected cases of antrum disease, and may be found with the perforating cannula one inch behind the anterior end of the inferior turbinate body and at the junction of the turbinate body with the external wall.

Eustachian Tube.—The Eustachian tube does not lie within the inferior meatus of the nose, but immediately behind its posterior border. It is on a level with the posterior end of the inferior turbinate body, and may be seen in anterior examinations of the nose if there is atrophy of the inferior turbinate body.

Openings.—The only opening of the inferior meatus is the opening of the lacrymal duct. This duct is guarded by a valve known as Hasner's valve, composed partly of mucous membrane derived from the external nasal wall, and partly of mucous membrane derived from the inferior turbinate body. It should be remembered that it is possible to probe the lacrymal duct from the nose upward as far as the termination of its bony canal. Advantages are claimed for this method of treatment in low strictures of the lacrymal duct.

THE MIDDLE MEATUS—*Its Boundaries:*—The middle meatus of the nose is the largest and most important part of the nasal space. It is bounded in front by a line drawn through the anterior end of the inferior turbinate body and the base of the nasal bone; behind, by a line drawn through the posterior end of the middle and inferior turbinate bodies; on its median side, by the nasal septum; and below, by the lower border of the inferior turbinate body and by a line drawn from its border to the

septum. It is bounded externally by the upper or external surface of the inferior turbinate body and by the external nasal wall. It is bounded above by the external or eye side of the middle turbinate body, by the under surface of the middle turbinate body, and by a line drawn from this under surface to the nasal septum.

The middle meatus lies in its upper part at the level of the lower half of the orbit, and at its lower part at the level of the upper part of the antrum. Like the inferior meatus, it possesses a large recess between the lower half of the orbit and the external surface of the middle turbinate body. This recess contains structures of considerable importance,—the hiatus semilunaris, the processus uncinatus, and the bulla ethmoidalis.

The Hiatus Semilunaris—The Processus Uncinatus—The Bulla Ethmoidalis.—There is a very decided confusion in the nomenclature applied to this deep furrow in the middle meatus of the nose, which extends from the floor of the frontal sinus above downward, and backward on the external wall of the nose until it terminates in the os maxillæ. Some anatomists use the term "hiatus semilunaris" to describe this groove; others call a part of it the "infundibulum," while still others divide it into three parts called, respectively, the "naso-frontal duct," "the infundibulum," and the "hiatus semilunaris." By others it is known as the "pre-bullar groove."

One must deplore this lamentable confusion of terms, for it interferes with a clear understanding of what is really meant in any given description. Mere names, however, do not mean much. The important thing for the student to remember is that in every instance there is present in the middle meatus a groove extending as has been described, and which receives any drainage that may come from the frontal sinus, anterior ethmoidal cells, and the antrum of Highmore. There is no confusion of terms in the two or three sulci which are found in the superior meatus which are known to all anatomists as the ethmoidal sulci,

Fig. 3.—1, Hiatus semilunaris. 2, Bulla ethmoidalis. 3, Processus uncinatus. 4, Frontal sinus from which a wire has been passed downward to the hiatus. 5, Antrum. 6, Sulci draining the ethmoid cells. 7, Part of middle turbinal raised to show the structures beneath it. 8, Sphenoidal sinus. The inferior turbinal is normal and is in place. The hiatus semilunaris in this case is nearly perpendicular.

and it seems to the writer that since this other groove in the middle meatus is analogous in size and direction and general conformation to the sulci in the superior meatus that it also might properly be termed a sulcus, and while he hesitates to suggest a new term, the confusion arising from the multidude of appellations for this one groove makes him feel that it would not be amiss should it be known merely as the *sulcus of the middle meatus.*

The hiatus semilunaris is no part of the groove. It is a plane stretching between the bulla ethmoidalis and the processus uncinatus. From the same standpoint, the term "infundibulum" could be applied only to the upper and anterior part of this groove—namely, that part which first receives the drainage from the frontal sinus. This would make it equivalent to the term naso-frontal duct.

In this work I shall not introduce the term sulcus of the middle meatus, which I have here proposed, but will retain the term "hiatus semilunaris" for the entire groove, for while this is etymologically incorrect, it is the term used by my most respected master, Professor E. Zuckerkandl, of Vienna, who may be considered the father of nasal anatomy.

If the middle turbinated is cut in such a way that it may be lifted upward and inward from its usual position, the large space of the middle meatus will come into view. While the middle turbinate is in its usual position, the middle meatus can be only partly seen. When the external wall of the middle meatus is exposed for examination, one sees constantly present a very deep sulcus which is covered ordinarily by the middle turbinate body. This deep sulcus extends from above downward and backward. It is generally somewhat like a crescent in shape, but a considerable variation may occur in its direction and shape. In some cases it is very oblique, almost horizontal, while in other cases the obliquity does not depart far from the perpendicular. This deep fossa is known as the hiatus semilunaris, and it extends

from .5 centimeter (¼ of an inch) from the anterior end of the middle turbinate body, and is about .5 centimeter above the attachment of the inferior turbinate body at the external wall. This deep sulcus is bounded in front by an anterior wall which is known as the processus uncinatus of the ethmoid; behind, by a rounded, more or less globular structure known as the bulla ethmoidalis.

These structures are constantly present on the external nasal wall, within a short distance of the inner bony wall of the orbit, and are important landmarks for the openings of some of the sinuses. When a probe is passed into the upper end of the hiatus semilunaris, it will be found that the hiatus branches into two arms like a **Y**. The most external of these leads either to a blind pouch or to an anterior ethmoidal cell. The internal branch of the hiatus semilunaris always leads into the frontal sinus. This arm of the hiatus semilunaris is called the naso-frontal duct. The direction of the branch leading to the blind pouch or into the anterior ethmoidal cell, is forward, upward, and outward, the outward inclination being about 70°. The other branch, which makes the naso-frontal duct, and leads into the frontal sinus, has a direction upward, very much forward, and slightly outward, its angle of external inclination being about 80°.

The posterior end of the hiatus semilunaris changes its direction and suddenly turns forward, outward, and downward. Here it leads into the antrum of Highmore. This posterior end, leading into the antrum of Highmore, is known as the antral orifice. Along the upper edge of the hiatus semilunaris, two to four openings may ordinarily be seen. These are the openings of the anterior ethmoidal cells, all of which drain into the hiatus semilunaris, or its immediate neighborhood.

It will be seen that this recess in the upper part of the middle meatus lying between the eye and the external surface of the middle turbinate contains a deep sulcus which drains the frontal

Fig. 4.—Section with Part of (1), The left middle turbinal, cut away above, to show (2) Processus uncinatus. 3, Bulla ethmoidalis. 4, Frontal sinus. 6 and 8, Posterior ethmoid cells. 7, Sphenoidal sinus. The inferior turbinal is normal in size and position. Behind it is the opening of the Eustachian tube. The processus uncinatus is cellular in this specimen (an accessory anterior ethmoid cell).

sinus, all of the anterior ethmoidal cells, and the antrum of Highmore. Pus coming from the frontal sinus will therefore be seen between the middle turbinate body and the external wall of the nose; pus coming from all of the anterior ethmoidal cells will be found in exactly the same locality; and pus coming from the antrum of Highmore will also be found in the middle meatus, but lower and farther back.

The recess behind the hiatus semilunaris has a broad surface which marks the floor of the anterior ethmoidal cells.

THE SUPERIOR MEATUS—*Boundaries:*—The superior meatus of the nose is the highest of the three divisions into which the internal nose is divided. It is bounded above by the roof of the nose, which corresponds to the plate separating the nasal mucous membrane from the dura covering the anterior lobe of the brain. It is bounded below by the lower border of the middle turbinate body, and by an imaginary line drawn at this level across the space to the nasal septum; it is bounded in the median line by the nasal septum, and on the external, or eye, side, by the inner or septal side of the middle turbinate body, and the whole of the inner wall of the posterior ethmoidal cells, a wall usually known as the superior turbinate body.

The external wall of the superior meatus is much nearer the median line than the external wall of either the inferior or the middle meatus. In the upper part of the superior meatus are found grooves on the septal and the turbinate wall for the distribution of the olfactory nerves.

The Ethmoidal Sulcii: Sinus Drainage.—This meatus is also characterized by the presence on its external wall of one, two, or three deep sulci which extend from before backward, and generally somewhat downward; the anterior ends of these sulci extend to the anterior third of the middle turbinate body on its septal or internal side. They are known as the ethmoidal sulci and are described—when there are three—as the superior, middle, and inferior ethmoidal sulci. These sulci receive the

drainage from the posterior ethmoidal cells, and conduct it downward and backward toward the naso-pharynx. All of the posterior ethmoidal cells empty into these ethmoidal sulci. Sometimes all of the cells open into one sulcus, sometimes there is a sulcus for each posterior ethmoidal cell.

In the superior meatus, at the superior posterior angle, is another sulcus or recess, between the anterior wall of the sphenoid and the ethmoid, which is known as the spheno-ethmoidal sulcus. A probe passed along the roof of the nose to the superior, posterior angle, then tilted slightly outward and pulled a short distance downward will make an entrance into the sphenoidal cavity through the normal opening of this sinus, which is located in the spheno-ethmoidal sulcus.

Superior Turbinate Body.—A word must be said about the superior turbinate body. Most anatomists describe the presence of a superior turbinate body, and text-books on rhinology show pictures of this body.

The term "superior turbinate body" is a misnomer, since this region does not contain any bony tissue of a turbinate character, like the inferior or middle turbinates. The part to which this name is given is really the inner wall of the posterior ethmoidal cells, and no part of it can be removed without breaking into these cells.

Fig. 5.—This section shows part of the frontal sinus, the hiatus semilunaris, an accessory opening into the antrum, the inferior turbinal body, the Eustachian tube opening behind this and the sphenoidal sinus, with a partial septum near its center. In front of this sphenoid are the posterior ethmoid cells (not opened) and between these two is the sphenoethmoidal sulcus. The middle turbinal body has been lifted upward to show the structures beneath it. It remains attached by part of its upper edge to the ethmoid body.

CHAPTER II.

FRONTAL SINUS.

HISTORICAL.

THE frontal sinus is a large accessory cavity of the nose and is located above the level of the nose. It is the most anterior of all the accessory sinuses, and also lies higher than any of the others. This sinus was known to the ancients, for wounds of the sinus were common at the time when darts and spears were used as weapons.

Dr. Jonathan Wright, in his monograph entitled "The Nose and Throat in Medical History," Matthews & Co., St. Louis, has collected some very interesting material, which the author desires to acknowledge as the source of the historical information used in this volume, and to which he refers the student who is desirous of further historical information.

Galen refers to the porosity of the bones of the head for the purpose of making them lighter. Basilius first described the frontal sinus and asserted that it was an air cavity. Jessen and Bartholinus (1601), however, believed that the frontal sinus contained a viscid liquid used for lubricating the eyeball. In 1642, Dr. Alexander Read speaks of the frontal sinus as double in childhood, but united in ripe age. Earlier surgeons were certainly familiar with wounds of the frontal sinus, for at the time when darts and spears were used as weapons, blows upon the head, in the region of the frontal sinus, were very common. It is stated in an old manuscript, "If from a wound in the forehead blood and air emerges, the wound will not be fatal; but if no air emerges the wound will probably be fatal." This citation shows that the ancients were acquainted with the fact that wounds of the head produced different results, and that the frontal sinus might be involved without a wound of the brain.

The earlier surgeons were also familiar with the formation of fistulæ and ulcerations following wounds of the frontal sinus, for these are spoken of by Ambrose Paré (1564), and by Fabricus Hildanus, both of whom describe wounds of these cavities, communicating with the orbit, and discharging their contents, as acrid and corrupted pus. They also observed exophthalmos, produced by frontal sinus disease. Paré and Palfin distinguished between frontal sinus wounds and cerebral wounds by saying that when the frontal sinus is wounded air can be blown from the nose through the wound and mucus issues from the wound; water injected into the wound will reach the nose or throat. These points show a clear differentiation between brain and frontal sinus wounds.

Verheyan and Beniveni (1507) described cases of worms in this cavity, and Morgagni (1762) trephined the frontal sinus.

Anatomy.

LOCATION.

The frontal sinuses are located one on each side of the median line of the forehead, over the eyebrows, and are pyramidal cavities. They are lined with mucous membrane, continuous with the nose by means of an opening for each sinus from the frontal sinus into the nose, known as the naso-frontal duct. This nasal opening is at the lower anterior and internal angle of the frontal sinus. The sinus lies between the two layers of the frontal bone above the eye, and occupies a varying distance over the supra-orbital ridge. The sinus presents for examination an anterior wall, a posterior wall, a roof, a floor, a base or septum, and an apex.

SEPTUM OR BASE.

The base of the frontal sinus lies against the base of the opposite side, the two bases are a bony septum which completely separates one sinus from the other. This septum should be in

Fig. 6.—Section Showing the Right Nasal Wall from the Nasal Side. A well-marked hiatus semilunaris. Its anterior wall, the processus uncinatus; and its posterior wall, the bulla ethmoidalis. Ethmoidal sulci behind this, and below a small accessory opening into the antrum. The inferior turbinal body is in place, but the middle turbinal has been removed. The superior turbinal, so-called, is well shown, *i.e.*, the posterior ethmoid cells.

the median line, but it may incline from the median line slightly or considerably, depending upon the size of the sinus of the opposite side. If the opposite sinus is small, the septum is apt to deviate considerably from the median position. The septum is complete, is never perforated except pathologically, and is composed of a thin layer of bone.

THE APEX.

The apex of the frontal sinus extends out over the eyebrow generally as far as the supra-orbital notch or foramen. There is a great variation, however, in the position of the apex. If the sinus is small, the apex may extend out a short distance from the median line. If it is an average sized sinus, the apex should be opposite the supra-orbital notch. If the sinus is rather large, it may extend a quarter or half an inch beyond this notch; and in very large sinuses the apex may extend as far out as the suture between the frontal and parietal bone.

THE ANTERIOR WALL.

The anterior wall of the frontal sinus is a lamina of solid bone, which is the anterior plate of the frontal bone. Its average thickness is 12 millimeters ($^1/_{16}$ of an inch). If the anterior wall of the frontal sinus bulges well forward, it materially increases the size of the sinus. It does not present anything of interest for examination on its facial surface, but on its posterior or sinus surface it presents near the beginning of the floor of the sinus a marked projection inward of the anterior plate, so as to form a prominent nipple or ridge at the junction of the anterior wall with the floor of the sinus. This ridge or nipple of bone serves to receive the base of the nasal bone.

THE POSTERIOR WALL.

The posterior wall of the frontal sinus is the posterior layer of the frontal bone. It inclines obliquely from the anterior

plate, in this way making the region of the floor of the sinus wider than its roof. This wall separates the sinus from the anterior lobe of the brain. The thickness is about the same as that of the anterior wall. Sometimes the posterior wall is very short and only slightly oblique. In such cases, the sinus does not extend far backward over the eyebrow, but is apt to end posteriorily just behind the nasal opening. In other cases, the wall is curved obliquely backward in such a way as to leave a space for the frontal sinus to extend over the eyebrow between the orbital plate and the posterior wall of the sinus. According to the convexity and obliquity of the posterior wall, the sinus may extend for only a very short distance over the eyebrow, or there may be a frontal sinus the whole distance of the length of the orbit, reaching nearly as far back as the optic foramen. In cases where the sinus extends over the eyebrow, the posterior wall of the sinus is a considerable distance from the nasal opening, so that in large sinuses there is no danger of perforation, if one makes an opening into the sinus from the nose; but in other cases where the wall is much less oblique, the posterior wall comes nearer the nasal opening, and is apt to be wounded or perforated in intra-nasal investigation of the sinus.

THE ROOF.

The roof of the frontal sinus marks the junction of the anterior and posterior plates of the frontal bone. It is apt to vary in height, an average roof being 1 centimeter above the supra-orbital ridge. In other cases the roof may be as high as 2 or 3 centimeters from the same point.

THE FLOOR.

ORBITAL AND NASO-FRONTAL PARTS.—The floor of the frontal sinus may be divided into two parts—the part which lies over the orbit and is known as the orbital part of the floor, and a second part which lies behind that part of the frontal bone

Fig. 7.—Section Showing Part of Right Half of the Head. Above is a large frontal sinus, with a considerable extension backward over the orbit. Below the orbit is a good-sized antrum cavity, and in front of this a stylus passed down the lacrymal duct, showing the nasal opening under the inferior turbinal body.

which articulates with the nasal process of the superior maxillary bone, and with the nasal bone. This latter part is termed the nasal part of the floor of the sinus. The length of the orbital part of the floor depends upon the development of the sinus externally over the eye and posteriorly over the orbit. In an average specimen, the orbital part is about 1 centimeter in length, and the nasal part is about .5 centimeter in length.

The orbital part of the frontal sinus presents nothing of interest for examination, except to remember that this part may be of considerable size if the sinus is well developed externally or extends for a considerable distance above the orbit between the orbital plate and the posterior wall of the sinus. It is often divided by partial septa or by folds of mucous membrane into several secondary cavities. The nasal part of the floor of the sinus is of great interest. It lies behind that part of the anterior wall which articulates with the nasal process of the superior maxillary bone and with the base of the nasal bone. Seen in perpendicular section, the nasal part presents for examination in front the anterior wall of the frontal bone. On the sinus side of this is a nipple or ridge. This bony ridge receives in front the base of the nasal bone and projects on an average 4 millimeters into the space of the sinus. Behind this prominent nipple or ridge, one comes at once upon an opening which communicates with the nose. This is the naso-frontal duct, the normal drainage canal of the frontal sinus. Behind the naso-frontal duct, one comes immediately upon the anterior wall of one of the ethmoidal cells.

NASO-FRONTAL DUCT.—It will be seen that the opening of the frontal sinus is in the nasal part of the floor, near the median line and just behind the nipple of bone which received the base of the nasal bone. On examining a skeleton specimen, it will be seen that the opening of the frontal sinus into the nose is always at the floor of the frontal sinus, and is just behind a **T** shaped suture which is formed by the articulation of the frontal

bone with the nasal and the superior maxillary bone. This **T** shaped suture is called the naso-fronto-superior maxillary suture, and at the juncture of the two lines of the **T**, if one were to trephine directly backward, one would enter the naso-frontal duct. This fact must be remembered, for in cases where the frontal sinus is suspected of being small or absent, the floor of the sinus may always be found by means of a small hole made through the naso-fronto-superior maxillary suture.

The naso-frontal duct therefore lies in the nasal part of the floor of the frontal sinus, and is bounded in front by the bony nipple which receives the base of the nasal bone, and behind by the anterior wall of the anterior ethmoidal cell.

The construction of the floor of the frontal sinus is such as to favor drainage. The whole floor of the frontal sinus inclines toward the naso-frontal duct; and if the naso-frontal duct is at all permeable the tendency of the sinus is toward good drainage. This cannot be said of the sphenoid or antrum, and explains the fact that if frontal sinuses are allowed to drain at all by a process analogous to taking the cork out of the small end of a funnel—that is, by removing the anterior end of the middle turbinate and the contraction of the adjacent swollen tissue, the disease in the frontal sinus will tend to speedy recovery. It also explains the relative infrequency of chronic empyema of the frontal sinus.

ANATOMY: LINING OF THE SINUS—VARIATIONS OF THE SINUS.
METHODS OF INSPECTION: BY SOUNDING—BY PROBE.

The nasal or inner part of the floor of the frontal sinus becomes an important part, when it is desired to enlarge the nasal opening. If a section of the skull is made at the level of the floor of the frontal sinus the front part of this section will show a bony wall which near the median line is composed of the base of the nasal bone. Immediately external to this is the nasal process of the superior maxillary bone articulating with a

Fig. 8.—This specimen shows very clearly a normal frontal sinus, its drainage into the hiatus semilunaris, the close relation of the anterior ethmoid cells to the floor of the sinus, a large development of ethmoid cells, a small sphenoid sinus, and the close relation between these last structures. One cannot tell where the ethmoid ends and the sphenoid begins. There is also a large accessory opening into the antrum of Highmore, and above this in the end of the hiatus is seen the small normal opening. Note particularly the development of an accessory anterior ethmoid cell in the processus uncinatus. The middle turbinal and the so-called superior turbinal are both removed.

rough place on the anterior wall of the frontal sinus. These three bony structures form the anterior wall of the frontal sinus at the level of the sinus floor. The bony part is generally .75 centimeter in thickness.

Posterior to this one comes upon the floor of the frontal sinus, which is known as the nasal part of the frontal sinus floor. Directly behind this bony part of the floor is the naso-frontal duct. Behind the naso-frontal duct, forming its posterior wall, is an anterior ethmoidal cell. Generally there is another anterior ethmoidal cell placed between the naso-frontal duct and the orbital cavity and lying in contact with the lacrymal bone. If it is not present, then the naso-frontal duct lies near the lacrymal bone. Nearer the median line, and internal to the frontal sinus is the olfactory fissure. This fissure contains two sulci, located in its anterior part for the transmission of the nasal nerves and arteries.

More toward the median line, it contains an opening by the side of the christa galli, which communicates directly with the brain cavity. Just external to this fissure, we have the nasal part of the sinus floor.

The Olfactory Fissure.—The olfactory fissure is bounded in front by the nasal process of the frontal bone; behind, by the junction of the perpendicular plate of the ethmoid and the sphenoid. Externally it is bounded by the processus uncinatus and by the opening of the frontal sinus, and on the inside by the christa galli. It communicates with the brain above and the nasal cavity below.

LINING OF THE FRONTAL SINUS.—The lining of the frontal sinus is continuous through the naso-frontal duct with the lining of the nose. It is composed of mucous membrane without any erectile tissue. It is lined with ciliated epithelium, is abundantly supplied with blood vessels, and is rich in mucous glands.

VARIATIONS OF THE FRONTAL SINUS.

No sinus varies so much as the frontal sinus in its size, position, or presence. It is not uncommon to find the frontal sinus undeveloped. In our cadaver courses considerable material is wasted because the frontal sinus is so often absent or small. Each year we expect to find three or four cases of absent frontal sinus.

ABSENCE OF FRONTAL SINUS.

When the frontal sinus is absent it gives no indication from any change in the exterior of the skull that it is not present, and clinically, transillumination of the region in which a sinus is absent will give the same picture as if the sinus were filled with pus. The frontal sinus in adults varies in size from one the size of a pea to one which is very extensive. I have seen sinuses which extended above the eyebrow 3 or 4 centimeters, externally as far as the parietal bone; and posteriorly, as far as the optic foramen. Quite frequently there is only a single frontal sinus. In such a case the other sinus may project into the region of the absent sinus, thus in a manner compensating for the absent one. Such sinuses, however, always belong to the side of the nose with which they communicate, and are therefore to be considered sinuses of that side.

The development of the frontal sinus explains why the sinus may vary so much in size or may be altogether absent. Between the third and sixth year, the end of the hiatus semilunaris, which has heretofore been a blind pouch, shows signs of activity and divides into two branches, one of which remains a blind pouch—the end of the semilunaris; the other branch pushes upward, reaches the frontal bone, and begins to form a sinus by enlarging its end, while it absorbs and separates the frontal bone as it develops. It is therefore clear that if a frontal sinus develops at all, or if it is unusually small, it can always be found in the

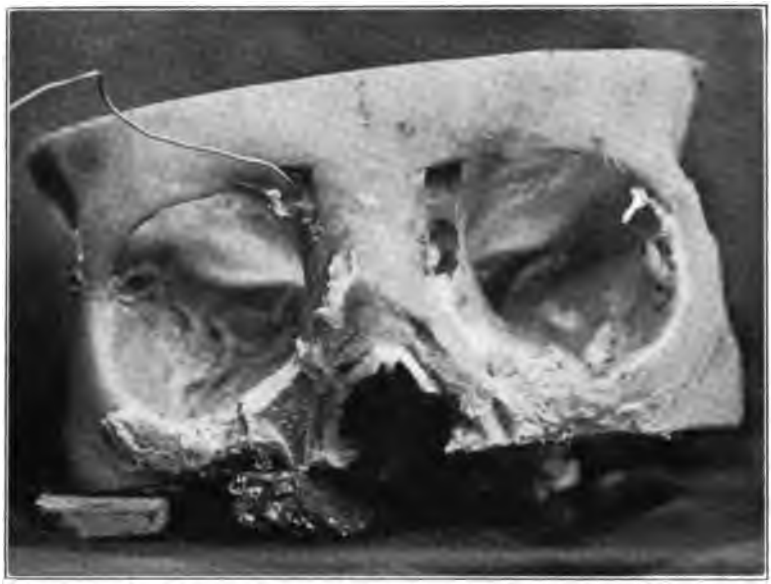


Fig. 9.—Absence of the Frontal Sinus on Both Sides. It is frequently undeveloped on one or both sides. These sinuses could not be found when operation was carried on as directed in this book, consequently the operator deserted this field above after he had reached the cancellous tissue, and made search at the T suture (fronto-naso-superior maxillary).

Fig. 10.—Frontal Sinus, Showing Septa and Pockets in the Sinus.

region of the frontal bone near the junction between the nasal bone and the nasal processes of the superior maxillary bone, which is the position of the naso-frontal duct and is marked by the naso-fronto-superior maxillary suture. In case of doubt as to the presence of a sinus during an operation, the operator should leave the supra-orbital region, explore the region of the naso-fronto superior maxillary suture, trephine horizontally backward, and if any sinus is present he will reach it, here at its lower point. If the sinus is absent, he will enter the nose instead of the brain.

This important safeguard in cases where the absence of the frontal sinus is suspected must not be forgotten by the operating surgeon. As the frontal sinus develops, it makes its way upward and outward over the superior orbital ridge and the orbit until it reaches its fullest development. Any disease of childhood producing interference with development before the sixth year may result in a lack of development of the frontal sinus. The other accessory cavities will be found generally well developed because they are all present at the time of birth.

In the same way, any disease of childhood interfering with the anatomical development of the individual may arrest the development of the frontal sinus.

PARTIAL SEPTA WITHIN THE FRONTAL SINUS.

When the frontal sinus is of large size, it is generally subdivided by partial bony septa, making deep recesses which are difficult to treat if the sinus becomes diseased. If the sinus is of small size, it generally consists of one chamber without septa. In a few cases where the sinus is absent on one side a large sinus is developed on the other side, which partially extends toward the side of the absent sinus. A septum may develop within such a sinus which will be so complete as to leave a doubt about the second sinus being present. In such cases, a probe passed so as to find the naso-frontal duct will not enter the nose, but will

pass into the opposite sinus near the floor, and from there enter the naso-frontal duct of the opposite side. This will decide the question as to the absence of the sinus on one side and the compensatory enlargement of the opposite sinus.

ANATOMICAL ABNORMALITIES.

In some cases when a frontal sinus is absent an anterior ethmoidal cell will push itself into the region of the frontal bone and will develop into an unusually large cell which will lie partly within the ethmoid and partly within the frontal bone.

Sometimes the floor of the frontal sinus is deeply indented and raised by the pushing upward of an anterior ethmoidal cell. In one case I have seen the frontal sinus empty through a special duct into the antrum of Highmore, the naso-frontal duct being absent and the hiatus semilunaris ending as a blind pouch. This abnormal drainage duct descended posterior to the lacrymal duct.

Generally the nasal opening of the frontal sinus is one of the anterior branches of the hiatus semilunaris. I have seen one case where the hiatus semilunaris divided into three sulci, the anterior one being a blind pouch; the second one led into an anterior ethmoidal cell; and the third, very indistinct and shallow, into the frontal sinus. This opening into the frontal sinus was posterior to and on a level with the opening of the bulla ethmoidalis.

RELATION TO THE ETHMOID CELLS.

The frontal sinus and the naso-frontal duct have an important relation with the most anterior of the ethmoidal cells. This anterior ethmoidal cell on its anterior wall above touches the floor of the frontal sinus, while slightly below it forms the posterior wall of the naso-frontal duct. This must not be forgotten, for it enables us to enlarge the opening from the frontal sinus into the nose by curetting away this anterior ethmoidal

Fig. 11.—Single Left Frontal Sinus Extending to Right Side. Right frontal sinus is absent, the apparent septum being within the left sinus.

Fig. 12.—A Frontal Sinus Containing Septa.

cell after we have opened the frontal sinus. Sometimes an anterior ethmoidal cell will bulge forward and upward, reaching the floor of the frontal sinus and indenting it, so that the frontal sinus may be very shallow antero-posteriorily and the ethmoid cell very large. Such an ethmoidal cell may be three or four times the size of the frontal sinus. In other cases, the anterior ethmoidal cell takes the place of the frontal sinus if that cavity is absent.

NASO-FRONTAL DUCT.

The naso-frontal duct is the opening of the frontal sinus into the nose. It is located in the nasal part of the floor of the frontal sinus and is about a quarter of an inch in length. It should not be given a separate name, but should be described as a part of the hiatus semilunaris with which it is continuous.

The naso-frontal duct is bounded in front by the ridge or nipple of bone which forms part of the frontal bone and serves as a resting place for the base of the nasal bone; it is bounded posteriorly by the anterior wall of the anterior ethmoidal cell; on the median side by a thick plate of bone which separates it from the olfactory fissure and the roof of the nose; and on the orbital side, sometimes by a small ethmoidal cell which is developed between the lacrymal bone and the naso-frontal duct, and sometimes only by the lacrymal bone.

This duct varies in size, but it is generally described as 3 millimeters in diameter. The direction of the naso-frontal duct from the nose into the frontal sinus is upward, forward, and very slightly outward; so that a probe, in order to reach the frontal sinus must be bent forward, upward, and slightly outward, and passed in this direction from the hiatus semilunaris.

The direction of the frontal sinus into the nose is downward, forward, and slightly inward. Most students fail to remember the fact that from the nose into the sinus it is slightly

outward, which explains the difficulty that many of them experience in probing these sinuses.

In a few abnormal anatomical cases the naso-frontal duct does not lead into the hiatus semilunaris. It may lead by a special foramen into the antrum of Highmore; sometimes into the bulla ethmoidalis; sometimes it may open on a line posterior to the hiatus on a line perpendicular to the opening of the bulla. These abnormalities explain the difficulty sometimes experienced in probing and washing the sinus.

Probing and Irrigation of the Frontal Sinus.

LANDMARKS.

When a frontal sinus is to be probed, the region of the middle meatus at the eye side of the middle turbinate must be carefully explored in order to locate the hiatus semilunaris. The three structures partially hidden by the middle turbinate body but which can be seen in the middle meatus on its external wall are—a thin process of bone, the processus uncinatus; behind which lies a deep sulcus, the hiatus semilunaris; and behind this the bulla ethmoidalis.

In order to obtain a view or an approach to this region, it is usually necessary to shove the middle turbinate body toward the nasal septum; or in some cases, to remove the anterior end of the middle turbinate, so as to expose the field for inspection. This is not necessary in wide nosed people or in cases of atrophic disease.

PROBING FRONTAL SINUS.

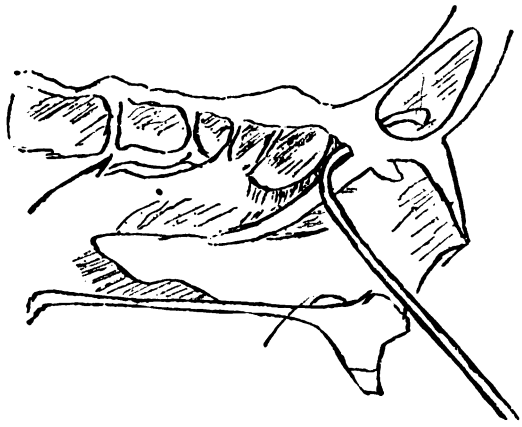
When the hiatus semilunaris has been exposed, a silver probe may be bent forward, upward, and slightly outward. It should have a tilt forward of 50°, and a bend outward of from 3° to 5°.

The end of the probe is introduced within the hiatus semilunaris and passed upward and forward. It will soon reach the

Fig. 13.—Perpendicular Section Seen from in Front. Note the deflection of the septum and the exostosis at its lower part with the cartilage in the center. The left inferior turbinal and the right inferior and middle are seen in cross-section. The left middle turbinal has been missed by the cut being somewhat oblique. Above are the frontal sinuses, with a septum dividing one from the other, and partial septa again dividing each cavity into irregular spaces. The section has been made too far forward to cut the antral cavities, but part of the lacrymal duct is shown on the left side. A stylus has been passed through from above.

end of the hiatus semilunaris, which is generally a blind pouch. It should then be withdrawn a little, turned slightly inward, and passed upward and outward. This time, if the opening of the frontal sinus is normal, it will pass into the naso-frontal duct and reach the frontal sinus, and will be felt by the patient on the anterior wall of the sinus over the eyebrow.

(For the distance from the end of the nose which the probe should pass, see the table of measurements, page 170.)



Shape of Probe Used to Enter the Frontal Sinus for Diagnostic Purposes. Behind the probe is the row of ethmoid cells. The probe hooks around the processus uncinatus.

The only absolute test that the probe is within the frontal sinus is to see it there by means of the Roentgen ray apparatus. Its entrance may be assumed, however, if it has passed the proper distance into a sinus and can be felt by the patient over the eyebrow. The probe, however, may not be in the frontal sinus. Instead, it may have passed into a very large ethmoidal cell, or into the long blind pouch of the hiatus semilunaris, or even into an ordinary sized anterior ethmoidal cell.

If there is any difficulty in locating the orifice of the sinus, the student should remember the variations in its openings, as

described when discussing the naso-fontal duct. I there said: "Pass the probe gently in the direction described, when you may possibly succeed in finding the opening, even if it is abnormal."

IRRIGATION OF THE FRONTAL SINUS.

After the probe has been passed and the locality of the frontal sinus determined, a similarly bent silver cannula attached to an irrigating syringe may be used to wash out the sinus for the purpose of ascertaining its contents. The proper irrigating syringe is shown in cut.

Care must be taken not to have the calibre of the cannula more than 4 millimeters in diameter. If the cannula is too large, it will fail to pass into the small naso-frontal duct. For the purposes of irrigation, a warm normal saline solution (1 drachm of salt to a pint of water) is the best solution to use.

When the sinus is irrigated care should be taken that all pus within the nose shall have been previously wiped away, so that any pus which is obtained may be identified as having come from the sinus. After the cannula attached to the syringe has been passed, the head is bent well forward over a pus basin and the saline solution is injected within the sinus. If the cannula fits the naso-frontal duct tightly, none of the fluid will be returned, but the patient will experience a decided sense of fullness and pain in the supra-orbital region. It is possible, under these circumstances, to suck back into the syringe a part of the fluid, and thus obtain undoubted evidence of the contents of the frontal sinus, without the possibility of the pus having come from any other part. If the cannula does not fit the naso-frontal duct tightly, then the fluid will return into the nose and run into the pus basin as quickly as it has been injected. In this way evidence of the disease of the frontal sinus may be obtained and the character of the secretion may be studied microscopically and bacteriologically. The washing of the sinus may be performed as a means of treatment as well as a method of diagnosis, and

Fig. 14.—This specimen shows a large frontal sinus, a series of ethmoid cells, with an accessory cell developed in the processus uncinatus, a full-sized sphenoidal cavity. A pin passes from the frontal sinus down to the hiatus semilunaris, and another holds a piece of the middle turbinal tissue to the base of the sphenoid. The rest of the middle turbinal has been removed. The inferior turbinal is in place.

sometimes much relief may be given to patients by repeated irrigation. Under such circumstances, it is usual to substitute for the normal salt solution certain medicated solutions for cleansing and disinfecting purposes. A solution of peroxide of hydrogen 1 to 10; or permanganate of potash, 1 to 4; or carbolic acid, 1 to 100; or Dobell's solution, the formula for which is as follows:—

℞ Sodii boratis 3j
Glyceriti acidi carbolici (U. S. P., 1870)..... 3ij
Sodii bicarbonatis 3j
Aquæ ..... ℥viij
M.

are favorite solutions for their effects upon the lining of membrane of the sinus. Other solutions are chlorid of zinc, 1 grain to the ounce; sulphate of zinc, 5 grains to the ounce; nitrate of silver, 10 grains to the ounce; and, in tubercular cases, a solution of iodoform and ether, 1 drachm to the ounce.

Should there be a necrosis of the posterior wall of the sinus, peroxid of hydrogen is a dangerous remedy to use, because the effervescence of the peroxid of hydorgen when brought in contact with pus will often produce pressure enough to send septic particles backward into the dura.

INTRA-NASAL OPERATION.

The subject of the washing out of the sinus naturally brings us to the discussion of what may be done by enlarging the opening of the naso-frontal duct from the nose into the sinus without producing an external scar. It is at once evident that such an operation is most desirable, since it allows drainage through the natural opening and does not subject the patient to loss of time from the more serious operation, or from the disturbance and interference with his daily life which arises from wearing an external dressing. To discuss this matter briefly, it may be said

that there are certain things which may be done intra-nasally in frontal sinus disease which are justifiable and safe; but an operation by which the naso-frontal duct shall be enlarged intra-nasally is one which is not justifiable, but is extremely dangerous and uncertain.

The procedures within the nose which are safe to perform to facilitate drainage from the frontal sinus are, first, the removal of the anterior tip of the middle turbinate body. This should be performed according to the operation described under "Turbinectomy" (see page 215). It is also justifiable to remove any obstructing tissue or polypi that we may find within the hiatus semilunaris, as well as to remove hypertrophy or polypoid tissue in the region of the bulla ethmoidalis, or the processus uncinatus. Should the processus uncinatus contain an accessory cell, or should its structure be much thickened, it is justifiable to remove the processus uncinatus with scissors and cutting forceps. The bulla ethmoidalis may in a similar manner be removed and its cell entered should it in any way obstruct the hiatus semilunaris. More than this it is not safe to do within the nose; and it is not entirely safe to enlarge the naso-frontal duct, even if you have been passing the irrigation cannula within the sinus repeatedly. The danger of entering the frontal sinus from the nose is that the brain cavity instead of the sinus may be entered. There are two places where this may occur, one in the olfactory fossa, which is immediately adjacent to the naso-frontal duct on its median side, and where the slight deviation of a millimeter inward would result in a perforation of the cribriform plate of the ethmoid bone; and the other, on the posterior wall of the sinus opposite the end of the naso-frontal duct. In a series of measurements I found in 200 dried skulls that the distance from the end of the naso-frontal duct perpendicularly upward at the posterior wall varied from 4 to 30 millimeters ($^1/_6$ to $1^1/_4$ inches), and that there was no evidence to be deduced from external examination as to the height of the sinus wall. With

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Fig. 15.—Frontal Sinus, with Ethmoid Cell Extending Into Sinus.

Fig. 16.—Frontal Sinus—Large Ethmoid Cell Extending Into Sinus.

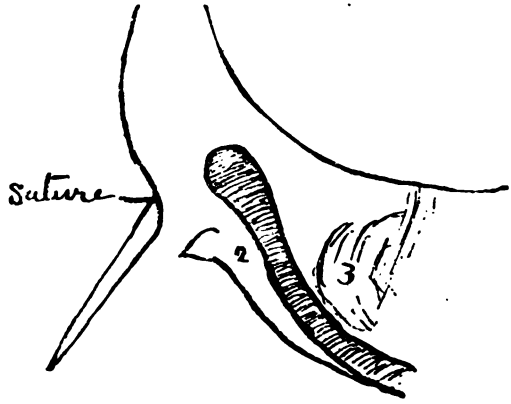


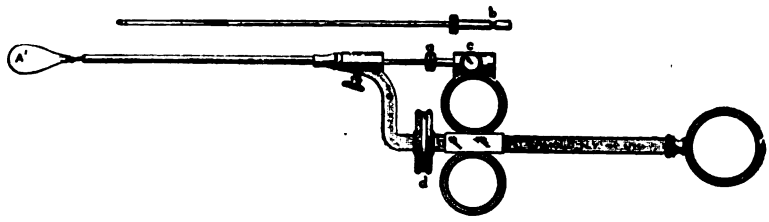
Fig. 17.—Absence of Frontal Sinus. Shaded part is infundibulum, with blind end.

Fig. 18.– Frontal Sinus and Outlet, Seen from in Front. Shows the ethmoid cells external, and the base of middle turbinate internal to duct.

such a variation in measurement as this—a distance between 4 and 30 millimeters—it may readily be seen that a cutting instrument used upon a part which is inaccessible to sight, might easily perforate through the brain plate if the posterior wall happened to approach the naso-frontal duct.

To sum up the matter of intra-nasal opening for the relief of frontal sinus disease, we may say that there are five reasons why it is not safe to operate through the nose:—

1. The frontal sinus may be absent.



Author's Nasal Snare.

2. The posterior wall of the roof of the sinus may be so near the naso-frontal duct as to render any operative procedure dangerous.

3. Because all the time that we have been irrigating or probing a large cavity we may not have reached the frontal sinus at all, but may have been irrigating and probing a large anterior ethmoid cell. (See Figs. 15 and 16.)

4. Because of the decided tendency of a cutting instrument to be deflected slightly toward the median line when cutting around the orifice of the naso-frontal duct. This deflection of even a millimeter toward the median line will send the cutting instrument into the olfactory fissure and directly into the brain.

5. Because of the variations in the location of the nasal opening of the naso-frontal duct.

Treatment of Frontal Sinus Suppuration: Conservative Methods.

The conservative treatment in frontal sinus disease consists:—

1. In the removal of the middle turbinate.
2. Cutting away the processus uncinatus.
3. The removal of any diseased adjacent parts.
4. The washing out of the sinus.

TURBINECTOMY.

A glance at the anatomy of the frontal sinus shows that the drainage from the hiatus semilunaris may be interfered with by any thickening of the middle turbinate body on its external or orbital side. As a preliminary to most frontal sinus work, the removal of the anterior end of the middle turbinate is desirable. This is performed generally by means of the scissors and snare, as described under "Turbinectomy" (page 215).

As soon as the anterior end of the middle turbinate has been removed, the region of the hiatus semilunaris comes into view and the technique of the washing out of the sinus is very much simplified. There are a few instances where it is not advisable to remove the middle turbinate body. This is the case if any attempt is to be made subsequently to increase the size of the naso-frontal duct by cutting away any of its anterior wall. In this procedure, the anterior end of the middle turbinate is a very valuable guide to insure safety. After the anterior end of the middle turbinate has been removed, a view of the region of the hiatus semilunaris and processus uncinatus may show that the processus uncinatus is very much hypertrophied, blocking up the space of the hiatus. It will then be necessary to remove the processus uncinatus with cutting forceps. Extreme care must be exercised in operating at the upper part of the processus uncinatus near its point of origin, for here at its base it has a

very intimate relation on its median side with the olfactory fossa which is very easily perforated. Most of the processus uncinatus, however, may be freely cut away and will facilitate drainage from the frontal sinus. Diseased tissue in this region, usually polypoid hypertrophies, may be seen springing from the mucous membrane in the region of an ethmoid cell or of the hiatus, in such a way as to plug the opening and prevent drainage from the sinus. All of this diseased tissue must be removed by cutting instruments and snare, until the pathway from the sinus is clear.

The sinus is now ready for washing. The subsequent treatment consists of injecting into the frontal sinus such medicaments and irrigating fluids as may be deemed advisable. The favorite solutions have been indicated in the discussion of probing and washing of the sinus.

The Operative Treatment.

The operative treatment upon the frontal sinus consists of (1) the trephine operation by which the sinus is exposed and may be explored; (2) an ordinary surgical opening through which the disease may be removed, and (3) a radical operation by means of which the entire interior of the sinus is exposed for treatment.

There are a number of radical operations upon the sinus called after the names of their originators.

TREPHINE OPERATION.

The trephine operation upon the frontal sinus is preliminary to all the others, since it is the operation by which we ascertain the presence of the sinus. An incision is made upon the suspected side, from the base of the nose and the median line slightly upward and outward, and follows the line of the eyebrow, extending as far outward as the supra-orbital notch. This notch or foramen can always be felt with the finger over the

inner third of the eyebrow. Through the supra-orbital foramen is transmitted the supra-orbital nerve and arteries. Care should be taken not to extend the cut far enough into it to incise these structures.

The first incision made through the entire thickness of the soft structures to the bone includes an incision through the skin, occipito-frontalis muscle, fascia, and periosteum. A periostiotome is then used to separate the periosteum and muscle upward as far as the limits of the wound will allow, and downward, so as to expose the supra-orbital ridge, and the edge of the roof of the orbit. The periostiotome must not split the periosteum beyond the point where the orbital roof begins. Considerable bleeding will occur, which must be controlled with artery clamps and ligatures.

The bone over the suspected frontal sinus area is now exposed, and the next step is the chiseling or drilling through the bone into the sinus.

RULE FOR FINDING FRONTAL SINUS.—The rule for finding the sinus is as follows:—

Draw an imaginary horizontal line through both supra-orbital notches. Drop a perpendicular line through this which will run midway between the inner canthus of the eye and the median line of the nose. Where these two lines meet they will form the inner and upper sides of a 6 millimeter (¼ inch) square, in which space, if the bone is removed, the sinus will be reached. The perpendicular line marks the course of the naso-frontal duct. The direction is indicated by probes placed according to the rule, and the bone is scratched with a chisel. The other two sides of the square are completed, leaving a quarter of an inch square scratched upon the bone.[1]

Over this region a drill or chisel is used to remove the anterior wall of the sinus. In the author's experience a chisel and

[1] All surgical descriptions are given as if the body were standing erect before the operator in the usual anatomical position.

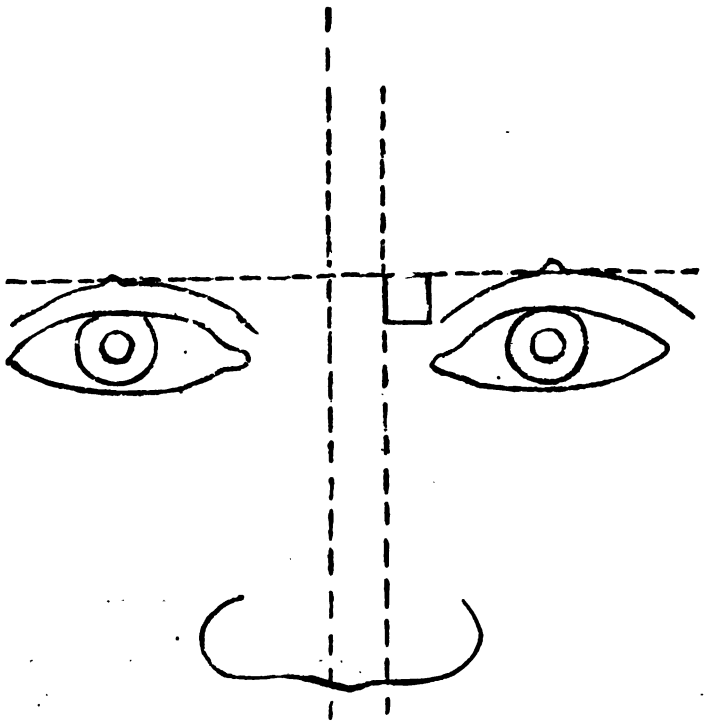


Fig. 19.—Diagram Showing the Positions of the Lines to Indicate Safe Place of Entrance in Searching for the Frontal Sinus. The horizontal line is drawn through the supra-orbital notches. The perpendicular is drawn half-way between the median line of the body and the inner canthus. The square is completed toward the eye.

Fig. 20.

Fig 21.

Fig. 20.—The Floor of the Frontal Sinus, seen from the Nose, showing also the Cribriform Plate and its relation to the Naso-frontal Duct.

Fig. 21.—The Floor of the Frontal Sinus, seen from above, showing the Naso-frontal Duct entering the Sinus and its intimate relation with the Olfactory Fissure.

mallet are the safer instruments to use. As soon as the thin plate of bone is removed the sinus is exposed. Sometimes a piece of mucous membrane is removed with the bone. When the sinus is opened, it bleeds freely.

If the operator has proceeded to the depth of 5 millimeters ($^1/_5$ inch) and has not reached the sinus, extreme caution must be used for fear of perforating the brain plate. A curette may now be substituted for the chisel or drill and the operator may work cautiously backward when he will soon come upon the sinus if it is present. If instead of reaching an air cavity he comes upon cancellous bone, it is necessary to proceed with extreme care. If after curetting this cancellous bone the operator comes upon another lamina of solid bone, he is probably upon the posterior plate of the frontal bone and the case is one where the sinus is absent. Under such circumstances the operator must at once retreat from this field of operation, and make an incision over the naso-fronto-superior maxillary suture, exposing the suture and cutting backward into the naso-frontal duct in this region. This is suggested as a safeguard to prevent perforation of the brain. It is not, however, a justifiable procedure until the operator suspects that the sinus is absent.

By cutting from 8 to 12 millimeters posterior to the naso-fronto-superior maxillary suture the operator will enter the naso-frontal duct if it is present, but if the sinus is absent, he will enter the nose instead of the brain.

If, however, the sinus proves to be normal and the presence of the sinus can be demonstrated, the operator should proceed to determine its extent. By exploration with a probe evidence will at once be adduced as to any purulent or mucous contents of the sinus, the condition of the mucous membrane lining can be demonstrated, and the presence of any growth or tumor ascertained.

This trephine operation is therefore not only preliminary to an ordinary operation, but it is a method of exploration and

diagnosis of extreme value. If the sinus has been found normal and the operator's technique aseptic, the field of operation may now be entirely closed by periosteal sutures, followed by muscle and skin sutures, and the field of operation left to heal by primary union. If the operation has demonstrated any disease of the sinus, it is the operator's duty to decide whether he will proceed with an ordinary or radical operation.

THE ORDINARY OPERATION.

The usual operation upon the frontal sinus consists in finding and trephining the sinus as described above, and then enlarging the opening already made until it is of sufficient size to allow a thorough removal of the lining membrane of the sinus and the proper treatment of the naso-frontal duct. The rongeur forceps or the chisel are the means ordinarily used to enlarge the opening, which should be about a centimeter (⅜ inch) in diameter. Through an opening of this size, bent curettes are passed and the entire contents of the sinus removed. Care must be taken to break down any thin spots of bone which partially pocket off the sinus, for these form dangerous recesses from which infected tissue constantly infects the healing tissue in the sinus, after the membrane has been removed. Care must be taken not to wound the naso-frontal duct too severely.

A blunt curette is passed into the naso-frontal duct and its walls are generally scraped to destroy the superficial layer of epithelium. The whole sinus is now thoroughly cleaned. A small piece of rubber tissue, half an inch in diameter, should be introduced within the sinus and carried by means of a probe into the naso-frontal duct. This should fit into the duct as a hollow cone and receive the end of the gauze packing. The object of this sheet of rubber tissue is to prevent the gauze from sticking to the naso-frontal duct, and to facilitate the isolation of the sinus from the nose. The rest of the sinus is now carefully packed with sterile gauze, and an ordinary surgical dressing is placed outside. The whole incision is left open.

Fig. 22.—Perpendicular Section, showing: 1, The middle turbinate (a part of the ethmoid bone). 2, The inferior turbinate crossing the center of the nasal wall of the antrum (9). 3, Cells in the lateral mass of the ethmoid bone. 4, Nasal septum, deflected. 5, Orbit. 6, Inferior nasal meatus. 7, Middle nasal meatus. 8, Superior nasal meatus.

The first dressing should not be changed for four or five days. The object of this operation is to produce a closure of the naso-frontal duct so as to shut the sinus off from the nose and in this way prevent reinfection of the sinus. The case should therefore be treated as an ordinary bone operation, in which the cavity of the bone is to be obliterated by granulation tissue.

The prognosis of the ordinary sinus operation is good if the sinus is small and if one succeeds in shutting the sinus off from the nose. The difficult cases to cure are those in which the sinus is large, where it extends for a considerable distance over the eye, or where it is divided into pockets by partial septa; reinfection almost always occurs from the nose, and this has led to the practical abolition of the old method of treatment, by which the drainage from the sinus was facilitated by breaking down the posterior wall of the naso-frontal duct, or by cutting out the anterior ethmoidal cell. While this facilitated drainage from the sinus into the nose, it also provoked infection from the blowing of pus from the nose into the sinus.

RADICAL OPERATION OF THE FRONTAL SINUS.

In performing the radical operation on the frontal sinus, one takes away the whole of the anterior wall of the sinus. This operation is generally performed on very chronic cases, or where the sinus is extremely large; but it is a disfiguring operation and should not be attempted until every other means has been exhausted. Some cases of necrosis of the posterior wall, or of tubercular disease, or very chronic fistula formation, may require it.

The preliminary steps of the operation consist of finding the sinus as has been described in the trephine operation. (See page 56.) After the sinus has been found and its dimensions determined with a probe, the external incision is continued through the eyebrow as far externally as the sinus extends. The peri-

osteotome then separates the soft tissue from the wall of the sinus and the anterior wall is removed by drills, bone forceps, and chisels. When this operation is properly done there are no overhanging edges, and the cancellous tissue of the frontal bone is exposed all around the edge of the sinus. It is never justifiable to destroy any part of the supra-orbital ridge, and care must be taken in working at the lower part of the anterior wall of the sinus not to crack any part of the orbital roof. The supra-orbital ridge is a very important factor in the cosmetic conformation of the face, and if the slightest change is made in the arch it produces an ugly flattening deformity of that side.

In the radical operation all pockets and partial septa must be destroyed and the entire sinus curetted thoroughly. The naso-frontal duct should be gently curetted, and the entire cavity left widely open for purposes of drainage and packing.

THE AFTER-TREATMENT of these cases consists of an attempt to obliterate the naso-frontal duct and the frequent repacking of the sinus with gauze until the sinus is filled with granulation tissue.

As the sinus heals it produces considerable retraction of the skin, and the result is generally a deep depressed scar over the forehead. Something may be done to relieve this depressed scar with a small tenotome and the injection of a paraffin pad. This sometimes acts favorably to relieve the deformity.

VARIETIES OF RADICAL OPERATION.—The radical operation described above is a type of operation. Modifications of this operation have been used by various surgeons, and those most commonly adopted will now be described in detail.

Operation of Nebinger-Praun.—Incision made in front of the naso-frontal suture at the edge of the orbit, reaching as far out as the supra-orbital foramen. Expose the bony wall. Chisel, beginning at the nasal bone; then the nasal part of the frontal bone; then a vertical chisel cut in the bone, from 3 to 4 centimeters long, following the frontal vein. The entire width of

the bone covering the sinus is now removed, the horizontal part of the floor is exposed, pus removed, mucous membrane curetted, and the entire naso-frontal duct widened.

Operation of Jansen.—Convex cut just above and parallel to the eyebrow, from the external edge of the orbit to the side of the root of the nose. The roof of the orbit is now exposed, and with a periosteotome the under wall of the frontal sinus is removed, and sometimes, in a large sinus, a part of the forward wall. Curettage. In this operation the ethmoid cells may easily be reached. Closure of the wound by granulation.

Old Operation of Killian.—Skin incision, beginning in the medial line, above the root of the nose, extending outward over the eyebrow; exposure of the periosteum in the region of the frontal sinus; temporary dislocation of the nasal bones outward; removal of all the bony parts from the base of the nasal bones to the naso-frontal duct; the infundibular cell is opened and a wide communication established with the nose. The nasal bones are replaced and the wound is closed in its under part. The frontal sinus is packed with iodoform gauze.

Killian's Radical Operation on the Frontal Sinus.—An incision is made over the suspected frontal sinus extending from the base of the nose through the eyebrow as far as the supra-orbital notch and as deep as the frontal bone. This should be bared with the periosteotome upward as far as possible and downward over the supra-orbital ridge, where the separation of the soft tissues from the bone should continue into the orbit at its inner and upper angle in such a way that the superior oblique muscle with its hook, together with the fat and fascia of the orbit, are separated from the bone. This completely exposes the floor of the frontal sinus. The operator then trephines the frontal sinus above the supra-orbital ridge, and when the sinus has been found, he removes, with sharp chisels, *the whole of the anterior wall of the frontal sinus except that part which forms the supra-orbital ridge.* The removal of bone is also continued

downward and inward toward the base of the nasal bone, and all of the triangular lower part of the anterior sinus wall is chiseled away until the naso-frontal duct is fully exposed to view. Blunt retractors are now introduced into the orbit so as to retract the soft orbital structure from the floor of the sinus. Great care must be taken not to wound the eyeball. The operator with an exceedingly sharp chisel cracks through the floor of the frontal sinus, removes *the whole of that part of the frontal bone which forms in common the floor of the frontal sinus and the roof of the orbit,* except the part directly under and continuous with the supra-orbital ridge, which should be left so as to form, with the upper part of the bony eyebrow, a bridge of bone. This bridge of bone is essential to preserve the contour of the face.

At this stage of the operation the anterior wall and the floor of the frontal sinus will have been completely removed, so that the sinus is exposed over the forehead and into the orbit, the only remains of the anterior wall of the sinus and of the floor of the orbit being a supra-orbital bridge of bone extending from the apex of the sinus in a curved line downward and inward to the nasal process of the superior maxillary bone. Great care must be taken in forming this bridge not to crack or tear the bone, for upon its successful formation depends the cosmetic result of the operation.

The sinus is now thoroughly curetted, and if it is thought desirable to attack the ethmoid cells this can be done at the inner lower part of the wound behind the nasal process of the superior maxillary bone. If the ethmoid cells are curetted care must be taken to preserve the lacrymal duct at the inner canthus of the eye. When the sinus has been thoroughly curetted and the naso-frontal duct enlarged into the nose by curettage of its external and posterior wall, a drainage-tube is introduced from the sinus into the nose through this enlarged naso-frontal duct. The fat tissues of the orbit are crowded up into the space formerly occupied by the floor of the frontal sinus and the external wound is

sutured. Considerable pressure must be made so as to keep the soft tissues of the orbit against the posterior wall of the sinus, as well as crowd the soft tissues of the forehead against the upper part of this posterior wall over the supra-orbital notch. In this way it is claimed that the time of healing is much shortened. Any irrigation of the sinus which may be necessary after the operation is carried on through the drainage tube, which should be left in place for two weeks.

If the ethmoid cells are destroyed at the same time that the sinus is operated upon, the drainage tube is not introduced, but the ethmoid cells and the frontal sinus are packed through the nose with iodoform gauze, the external wound being closed as above described.

The results of the Killian operation are, as in all other radical operations on the frontal sinus, excellent when the sinuses are small or of medium size, but it is accompanied by considerable deformity and flattening of the face if the sinuses are large.

Operation of Luc-Ogden.—Incision at the inner third of the edge of the orbit, extending 1 centimeter to the right of the nose; exposure of the bone of the forehead on the frontal and orbital side; the frontal sinus is opened slightly exterior to the median line; a large communication is made between the frontal sinus and the nose, into which a drain is placed, and the external wound is closed.

Operation of Czerny.—Osteoplastic opening of the frontal sinus; a half-round concave incision over the region of the frontal sinus, extending to the periosteum in the line of this same incision. The bone is chiseled, and when the sinus is found the bone flap attached to the skin and muscle is lifted; the sinus is curetted and cleaned, the opening into the nose enlarged, and a drainage tube introduced. The sinus and wound may then be packed with iodoform gauze and when the pus has ceased to flow

—in about four weeks—the packing may be removed and the bone and skin flap pressed into place.

Operation of Kuhnt.—This operation is similar to the one described above in detail, as the radical operation on the frontal sinus.

Fig. 23.—The Ethmoid Cells, Seen from Above. 2, Nasal septum. 3, Naso-frontal duct. 4, Posterior ethmoid cells abutting the (6) Sphenoid sinus. 5, Orbit.

CHAPTER III.

ETHMOID SINUS.

HISTORICAL.

THE ethmoids have always been known as sievelike bodies, in fact this is the meaning of the word. Galen (B. 130 A.D.), in his "Instrumentum Odoratus," speaks of the ethmoid cells and indicates that their function is that of a sieve. He believed that the secretions from the nose escaped from the brain and were strained through the ethmoid bones before passing into the channels of the nose. The ancients had no conception of the mucous glands of the nose, and could account for the existence of the nasal secretions only by some such explanation as this. Galen later asserted that the bones of this region should be called spongy, not sievelike. About 1550, Berengar boldly opposed the views of Galen, in denying that the secretion from the nose was the result of filtration from the brain.. His ingenious explanation of the ethmoid bones and the cribriform plate was that their function, instead of being sievelike, was for the purpose of transmitting air and odors to the brain. For this he was spurned and insulted by the schools of the day for daring to criticise the authority of Galen in this or any other particular. Schneider's work, in a much later day, upset these earlier theories, and attributed to the nasal mucous membrane its true function of secretion and olfaction.

From the time of Galen until very modern times, 1891, not much work was done upon the ethmoid cells, when Bosworth published a paper upon various forms of disease of the ethmoid cells, and Grunewald published another on affections of the frontal sinus, in which ethmoiditis is mentioned.

ANATOMY.

DIVISION BY DRAINAGE.

The ethmoid sinus—ordinarily termed the ethmoid cells—is a sinus which is always divided into at least two compartments, which are distinguished from each other by their locality and method of drainage. These are the anterior ethmoidal cells and the posterior ethmoidal cells. *All the anterior ethmoidal cells always drain into the middle meatus, and the posterior ethmoidal cells drain into the superior meatus.*

BOUNDARIES.

The region of the ethmoidal cells, or the ethmoidal sinus, lies between the external wall of the nose and the orbit. These cells are bounded above by the plate of bone which separates them from the anterior lobe of the brain; externally, by the orbital plate of the ethmoid *(os planum* or *lamina papyracea);* internally, by their own internal wall, known as the superior turbinate body; and below, the floor of the cells has a relation with the antrum of Highmore and with the middle meatus. In front, they are bounded by the posterior surface of the frontal sinus, by the naso-frontal duct and the hiatus semilunaris; and behind by the sphenoidal sinus (see cut). The ethmoid sinus is ordinarily 2 ½ or 3 centimeters in length, while its thickness anteriorly is slightly less than a centimeter, and behind 1 ½ centimeters. From above downward the cells generally occupy a distance of 1 ½ centimeters. The number of the cells varies in different individuals, but there are always at least two and may be as many as eleven or twelve. Ordinarily there are more anterior than posterior cells, and generally the anterior ones are smaller. All ethmoidal cells should be described as having a separate nasal opening, and this is generally true, although sometimes large cells apparently are made to communicate one with

Fig. 24.—Perpendicular Section, Showing the Right Side. 1, Middle turbinal partly removed, showing (2) The processus uncinatus. 3, The bulla ethmoidalis. 4, Frontal sinus draining into the hiatus semilunaris—the dark line between 2 and 3. 5, Sphenoid sinus—a large one. 6, Wall of posterior ethmoid cells (superior turbinal). 7, The inferior turbinal body. 8, Opening of the Eustachian tube.

the other by pathological conditions or by the development within a large ethmoidal cell of partial septa, which, by making a diverticulum or pocket, gives the appearance of a communicating cell. As a rule, however, it may be stated that for each complete ethmoidal cell there is a separate nasal opening.

THE ETHMOIDAL CELL WALLS.

The term "ethmoid" means sievelike, and this descriptive word gives an idea of the fragility of the boundary structures. It is here that one finds the thinnest plate of bone separating the brain from the nasal cavity, and partitions of thin bone separating the cells from each other and from the orbit. These separating walls are scarcely thicker than tissue paper. The partitions between the cells are thin plates of bone which stretch directly across the cavity of the ethmoid sinus from the *os planum* of the ethmoid to the inner wall of the ethmoid cell (the superior turbinate body), thus dividing it into smaller cells or chambers.

ANTERIOR AND POSTERIOR ETHMOIDAL CELLS.

This division of the ethmoid cells into anterior and posterior cells is a classification somewhat different from that of certain other authors who confuse students with the terms anterior, middle, and posterior ethmoidal cells. In the classification which is here given, it is to be distinctly understood that any ethmoidal cell which normally drains into the middle meatus of the nose belongs to the anterior ethmoidal cell group; and that all the ethmoidal cells which normally drain into the superior meatus of the nose belong to the posterior ethmoidal cell group.

Other cells which are to be described below as accessory cells are those which, by certain other nomenclatures, are known as anterior ethmoidal cells.

If in an anatomical specimen a middle turbinate body is cut from its base, the specimen tilted upon its side, and a view obtained of the region of the hiatus semilunaris, generally two, three, or four openings may be seen communicating with this region which do not look unlike the view which one obtains by looking into a honey-comb. These are the openings of the anterior ethmoidal cells, and a probe may be passed through each of them into distinct and separate cells. Ordinarily one can demonstrate two or three of these openings. One of these openings is always seen posterior to the edge of the bulla ethmoidalis, and is the drainage opening of the bulla (see cut). All of the anterior ethmoidal cells will discharge their contents into the middle meatus of the nose near the region of the hiatus semilunaris. If the contents of these cells are purulent, then the locality of the pus in disease of the anterior ethmoidal cells will be in the middle meatus of the nose between the external wall of the nose and the external surface of the middle turbinate body, and the pus will flow down from the hiatus semilunaris either into the antrum or upon the floor of the nose (see cut).

A search for the openings of the posterior ethmoidal cells shows that each cell communicates by a separate nasal opening with one of the two ethmoidal sulci within the superior meatus (see cut). A probe passed into an ethmoidal sulcus will find at its end an opening which leads into a posterior ethmoidal cell. The contents of the posterior ethmoidal cells are discharged into the superior meatus, and if the discharge is purulent the locality of the appearance of the pus will be different from that in disease of the anterior ethmoidal cells—that is, the pus will never be found in the middle meatus, but will be seen in the superior meatus of the nose, and always to the septal or internal side of the middle turbinate body. Sometimes it may be seen by a rhinoscopic mirror flowing from the ethmoidal sulci into the naso-pharynx.

At this time it will be well to definitely state what informa-

Fig. 25.—View of the Ethmoid Cells and Sphenoid Sinuses, Cut Horizontally; Seen from Above. Note the irregularity of the cell structures; they are wider behind than in front. The sphenoid sinuses on either side posteriorly have partial septa in their interior. The nasal septum is almost straight, and where it joins the sphenoid behind, a good picture of the spheno-ethmoid sulci is seen.

tion may be obtained about sinus disease from a study of the point of appearance of a pus discharge.

LOCATION OF PUS.

If pus is found in the middle meatus and is located well upward and forward within the hiatus semilunaris, and its flow is checked by plugging the hiatus, it probably comes from the frontal sinus.

If the pus is in the same locality and its flow is not checked by plugging the upper part of the hiatus, it probably comes from some of the anterior ethmoidal cells.

If the upper part of the middle meatus is plugged and the pus continues to flow, it probably comes through the lower part of the hiatus semilunaris, through the opening of the antrum of Highmore. This may be verified by tipping the head to the opposite side and lowering it, when the flow of pus will be increased if it comes from the antrum.

When pus is not seen within the middle meatus or to the eye side of the middle turbinate body, but is discovered coming down between the septum and the middle turbinate, it probably comes from the posterior ethmoidal cells. If the posterior ethmoidal cells are involved, the pus may be seen with a rhinoscopic mirror coming from the ethmoidal sulci.

If the pus is well confined to the posterior pharyngeal wall and the ethmoidal sulci are free, its origin is probably in the sphenoidal sinus.

RELATION BETWEEN THE ANTERIOR AND POSTERIOR ETHMOIDAL CELLS.

I think it is clear now, from what has already been said, that there is absolutely no relation between the anterior and the posterior ethmoidal cells except that of contiguity. If any communication exists between the anterior and posterior ethmoid cells it must be considered pathological.

ACCESSORY ETHMOIDAL CELLS.

Accessory ethmoidal cells are developed in the processus uncinatus, the angular process of the ethmoid bone, within the middle turbinate, and in the sphenoid. The first three of these cells belong to the anterior ethmoidal cells; the last one, to the posterior ethmoidal cells.

The cells which develop within the processus uncinatus change that structure from a thin process to a wide, round, bulging process, which is often confused with the bulla ethmoidalis. I have seen three cells developed within this process. Their openings are always in the region of the hiatus semilunaris in the middle meatus.

The angular process of the ethmoid may develop one or two cells. These are usually small, and also open in the region of the hiatus semilunaris.

The middle turbinate sometimes develops an accessory ethmoidal cell which communicates by a curved opening with another of the regular anterior ethmoidal cells. This form of cellular development within the middle turbinate body was formerly considered pathological and ascribed to diseased conditions of the middle turbinate body. It was clinically diagnosed as a bony cystic turbinate. Elaborate pathological theories failed to explain their presence, until they were finally considered abnormalities of anatomy.

The only accessory posterior ethmoidal cell is one which may develop within the smaller wings of the sphenoid bone. These are sometimes called accessory sphenoidal cavities. One kind of an accessory sphenoidal cavity was described by me in a paper, entitled "The Relations of the Ethmoid Cells to the Sphenoid." I gave particular attention to the sinus in the small wings of the sphenoid (Monatschrift für Orenh., Berlin, 1901, 35,392) and attempted to classify a form of sinus, one variety of which originally communicated with the posterior ethmoidal

Fig. 26.—View of the Cross (Horizontal) Section Through the Ethmoid Cells and Sphenoidal Sinuses. Note the wider posterior cells. The nasal septum ends at the sphenoid and the septum between the two cavities in the sphenoid bone is over to the left, making a larger right sphenoidal sinus. Note the fact that the ethmoid cells posteriorly abut on the sphenoidal sinuses.

cell. I am convinced from further observation in other similar cases that this kind of cell should be looked upon as an accessory posterior ethmoidal cell.

RELATION TO OTHER ORGANS.

The ethmoid sinus has some very important relations. Above lies the brain; outside, the eye; below, the nose and antrum; behind, the sphenoid. Besides these important relations, operative work upon the ethmoid is made difficult from the fact that the width of the cells varies considerably in different individuals, and give no external indication of their width. It is impossible before operating upon a case to know whether the ethmoidal cells belong to the narrow or wide class. Because of the frequency of operations upon the ethmoid, and the danger of perforating the eye and the brain, it becomes necessary to secure certain and safe landmarks from which points the operator may work without danger.

In looking for these guides to operation, we must not forget that some intimation of the width of the cells, and especially of the nearness of the cutting instrument to the orbital plate, may be gained if the operator introduces his finger along the inner canthus of the eye at the moment of operating. The other guides to safe operation upon the ethmoids are the hiatus semilunaris, the bulla ethmoidalis, and the whole of the free nasal border of the ethmoidal cells in the middle meatus. If a cross-section of the ethmoid cells is studied it will be seen that the eye-plate forms the outer boundary; the brain-plate, the roof; while a part of the floor and inner wall of the ethmoid cells projects free within the nasal cavity.

By a glance at the next plate, it will be seen that we are able by removing a small part of the lower and inner wall of the ethmoid cells to make a large opening which will serve every purpose of drainage. In the removal of this part, if one cuts

away the floor of the ethmoid cells, it is done without removing the middle turbinate. If the inner wall is removed, it is done after the middle turbinate has been removed by continuing to cut away the stump of this turbinate. These two walls form a safe and ready guide for entrance into the cells without danger of perforation of the orbit or the brain. The most important guide is the bulla ethmoidalis. In the middle meatus of the nose, the processus uncinatus, the hiatus, and the floor are always to be found. They are readily identified. The processus is thin and narrow; behind it lies a ditch which is the hiatus; back of these is a bulbous prominence which is the bulla. These structures are covered by the anterior end of the middle turbinate, which must be removed or shoved aside to disclose their presence.

The large, rounded, bulbous prominence lying immediately behind the sulcus or ditch is the bulla ethmoidalis, the largest and most prominent of the ethmoidal cells, for if we break through the thin wall of the bulla we come at once into a cavity (see cut). If we continue to cut on the same horizontal and perpendicular level which we used to open the bulla, we can continue to open the anterior and then the posterior ethmoidal cells without danger of wounding either the eye or the brain.

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DIAGNOSIS OF ETHMOIDITIS.

Empyemata of the ethmoid cells are divisible into one kind which is known as *open empyema,* and another kind called *closed empyema.*

The term, open empyema, is applied to a diseased cell or group of cells from which the discharge issues with little or no obstruction. The term, closed empyema, is applied to a diseased cell or group of cells in which the discharge does not find an outlet, but is retained as a cyst within the cell, producing in time characteristic symptoms from pressure or deformities from enlargement of the cell. It is the closed empyemas which perfo-

Fig. 27.—The ribbon is passed through an opened accessory anterior ethmoid cell developed in the processus uncinatus, draining into the hiatus semilunaris. Above is an accessory ethmoid cell crowding upward to the floor of the frontal sinus. Posteriorly, a large sphenoid sinus.

rate bordering cavities, such as the brain and the orbit. This variety of closed empyema is not confined to the ethmoidal cells. It is seen in the frontal and the sphenoidal sinuses, but rarely in the antrum.

In an open and discharging empyema we are aided in our diagnosis by the locality of the pus. When pus is found in the middle meatus of the nose, at the external or eye side of the middle turbinate body, it should be traced to its source by means of pledgets of cotton wound upon applicators. As the pus is carefully wiped away, it can be traced higher and higher to its source, until the investigator can definitely determine that it does not come from the antrum of Highmore. If a probe covered with cotton is now applied to the region of the naso-frontal duct, in such a way as to block it, and the pus continues to flow over the posterior edge of the hiatus semilunaris and from the region of the bulla ethmoidalis, it is safe to conclude that it is coming from the anterior ethmoidal cells and that we have to deal with a case of open empyema of the anterior ethmoidal cells.

On the other hand, if the pus when first discerned is found at the septal or inner side of the middle turbinate body, it must come from the superior meatus of the nose, and in this region we have only the drainage from the posterior ethmoidal cells and the sphenoidal sinus. A small quantity of pus found in this locality does not necessarily indicate disease of these sinuses, but its continued reappearance after it is removed indicates the possibility of their involvement, and the rhinoscopic mirror and palate retractor should now be used for a complete examination of the naso-pharynx.

If the pus is coming from the posterior ethmoidal cells it will be seen flowing from the ethmoidal sulci. It is often quite easy to demonstrate pus coming from this region if the nose is not filled with polypi. If the nose is filled with inflammatory growths of any kind it is frequently necessary to remove all of them before the source of the pus may be disclosed.

DIAGNOSIS OF CLOSED EMPYEMA.—These cases do not discharge. The pus is retained within the group of diseased cells, and as it is formed its pressure distends the cells and deforms the walls. If this pressure is exerted intra-nasally, it results in the middle turbinate being forced against the nasal septum and the cell walls of the anterior ethmoidal cells are pressed over with it, so that they are found bulging inward toward the septum. Sometimes these cells are enlarged downward also into the middle meatus.

For some unknown reason the closed empyemas which affect the posterior ethmoidal cells have a greater tendency to perforate into the orbit than those which affect the anterior ethmoidal cells. Closed empyemas of the posterior ethmoidal cells frequently perforate into the orbit, thus setting up an orbital cellulitis or an exophthalmos; while the closed empyemas of the anterior ethmoidal cells are more apt to perforate the brain, or more frequently open into the nose itself.

When a closed empyema of the posterior ethmoidal cells has perforated the orbit, and this most often occurs in children, it becomes immediately infected, tender, painful, and the eye displaced, so that a marked exophthalmos results. At the same time the upper lid is swollen and reddened. Fluctuation is generally easily made out in the upper lid.

In order to reach this pus, a curved incision should be made, extending from the roof of the nose upward over a third of the orbital roof. A periosteal elevator should separate the periosteum from the bone, and with this same instrument the operator should work carefully backward along the inner wall of the orbit, and the source of the pus will soon be reached. If a probe is now carefully used, it will invariably enter one of the posterior ethmoidal cells.

Closed empyema of the anterior ethmoidal cells occasionally do not open into the brain or the nose, but have been known to form a swelling along the inner orbital wall above the inner

Fig. 28.—External Nasal Wall, with Accessory Ethmoidal Cells in the Processus Uncinatus. The tube (1) lies in the frontal sinus and naso-frontal duct.

canthus. A few of these have been diagnosed osteoma or exostosis of the orbit, and upon operating they have been found to consist of the thinnest possible shell of bone having purulent contents. In these cases it is easy to establish drainage within the nose by curettage and washing.

Cases of closed empyema which perforate the brain are ordinarily not diagnosed until after the brain abscess is well advanced. They are generally fatal.

Closed Empyemas of Lesser Importance.—Closed empyemas frequently occur within certain of the ethmoid cells where they do not tend to become dangerous by extension or perforation. Such empyemata are found within the bulla ethmoidalis, the cells of the processus uncinatus, and in the accessory cells of the middle turbinate body. Circumscribed empyema of the bulla ethmoidalis manifests itself by displacement and enlargement of the bulla intra-nasally, and the displacement of the middle turbinated toward the septum. This locality is then frequently the site of polyp formation, and the diagnosis is made after the polyps have been removed from the sides of the enlarged bulla. A probe perforating the walls of the bulla discloses the presence of pus.

Sometimes the accessory cells in the processus uncinatus are the seat of infection and give rise to an enormous swelling of the processus uncinatus, displacing the middle turbinate and inducing a considerable swelling in the middle meatus. Its clinical course is similar to the same disease within the bulla and it is ordinarily discovered in the same way.

The empyemas in the accessory cells of the middle turbinate body are generally not discovered until the end of the turbinate has been removed on account of its size—then the cavity within the turbinated body will be found filled with pus.

The symptomatology of ethmoiditis does not interest us in a book of this kind, but it is well enough to mention that these cases are very frequent, that the patient is in constant danger

of a general septic infection, and that cerebral disturbances of a mild nature, neurasthenia, confusion of ideas, inability of concentration, lack of application to employment, general listleness and nervousness, and chronic headache, with pressure over the bridge of the nose are very frequent symptoms of even slight involvement of the ethmoid cells.

Treatment of Ethmoiditis.

When the diagnosis of empyema of the ethmoid cells has been made it is generally necessary to operate in order to relieve the case. The simplest thing to do for such cases is to remove the anterior end of the middle turbinate body and any other obstructing part which may act to block up drainage from the cell. The anterior end of the middle turbinate is first removed. Oftentimes the removal of this part will be the only thing necessary to secure good drainage from the cells and their gradual cure. Some authors, however, do not approve of this plan, but proceed at once to open the anterior ethmoidal cells.

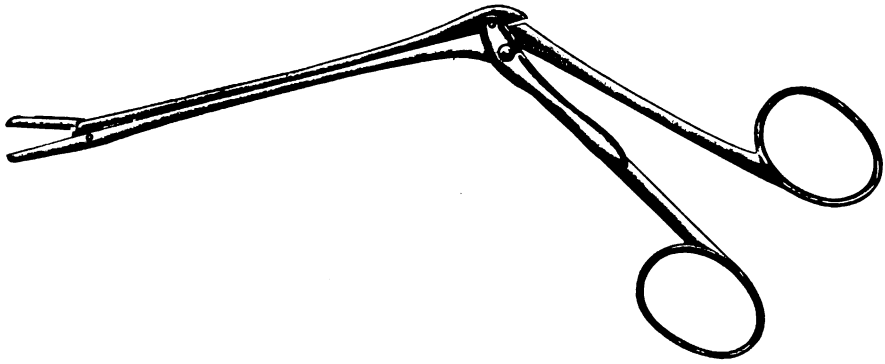
Opening the Anterior Ethmoidal Cells.

Preliminary to this operation the anterior end of the middle turbinate is ordinarily removed. Some operators do not remove it, but push it aside toward the nasal septum, in this way gaining a space by which the bulla ethmoidalis may be reached. After the middle turbinate has been removed or shoved aside, the region of the ethmoid cells is located by means of three anatomical landmarks—the hiatus semilunaris, the processus uncinatus, and the bulla ethmoidalis. When these three structures have been recognized on the outer nasal wall, the instrument which is to be used to perforate these cells is pressed against the bulla ethmoidalis and this cell is broken open. Sometimes a dental drill is used to perforate these cells, other operators prefer a

Fig. 29.—A Section of the Ethmoid Cells—Cut Horizontally and Seen from Above.

curette. In my experience, the best instrument is an alligator cutting forceps (see cut).

After an entrance into the anterior ethmoidal cell has been made through the bulla, the instrument used for the destruction of the cell is worked progressively horizontally backward without any deviation from the line of its introduction. If this is carefully done and the instrument has been introduced parallel to the median line, there will be no danger of perforation of the



Author's Cutting Forceps.

brain or of the orbit. If the instrument is allowed to work obliquely upward or at an angle outward, either the brain or the orbital plate may be perforated.

After a free opening has been made within the anterior ethmoidal cells, the partitions may be carefully removed by gently scraping with the curette or by continuing to cut them out piecemeal with the cutting forceps. The instrument should always work toward the turbinate and away from the orbit. After the cells have been cut out for a space of 1 ½ or 2 centimeters, the operator will be in the region of the posterior ethmoidal cells, and if he does not care to open these cells the operation must be stopped at this point. Hæmorrhage is always very profuse

and annoying. It is sometimes controlled by packing with gauze, and continuing the work after the packing has been removed. For the purpose of aiding the cessation of bleeding, adrenalin chlorid, solution of 1 to 10,000, or a solution of acetotartarate of aluminum, 1 drachm to the ounce, may be used on the pledgets of cotton or gauze. A part of the diseased membrane should always be preserved for microscopical study.

TO OPEN THE POSTERIOR ETHMOIDAL CELLS.

The posterior ethmoidal cells are opened from the anterior ethmoidal cells, and one or more of these cells are generally opened in an anterior operation. In order to thoroughly remove the posterior cells, it is always necessary to take away the anterior end of the middle turbinate body. Then the anterior cells are entered, as above described, and after they have been cleaned out the posterior cells are reached by following the same rules given for the removal of the anterior cells.

When both the anterior and posterior cells have been removed, the instrument will have made a space of about 3 centimeters in length, and the base of the middle turbinate and the region of the superior turbinate will have been removed.

In operating upon the posterior ethmoidal cells there is not much danger of perforation of the brain, but the danger of the perforation of the orbit is materially increased. The brain-plate posteriorly is thicker than it is anteriorly, and the brain substance is consequently better protected. After the greater part of the cells have been removed, granulation tissue, pieces of bone and shreds of mucous membrane always remain. These must be carefully removed, otherwise the pieces become necrosed or inflamed and produce exuberant granulation tissue or sepsis. A curette is ordinarily advised to complete the removal of these pieces of tissue from these cells, but it has always seemed to me to be a very dangerous instrument, and the danger of perforation

Fig. 30.—The so-called "cystic" middle turbinal has been cut open (1). The inferior and "superior" turbinals are both in place. In front is the frontal sinus, and a good-sized sphenoidal sinus is shown posteriorly. The opening of the Eustachian tube is also seen.

of the brain and the orbit are considerably increased by its use. The same work may be much more safely accomplished by means of small and sharp cutting forceps.

Extra-nasal Opening of the Ethmoid Cells.

The ethmoid cells may be reached through the frontal sinus by breaking down the lower part of the posterior wall of the frontal sinus (see Fig. 14).

An entrance is thus gained into the anterior ethmoidal cells, and by continuing the cutting out process the cells may be completely cleaned out. In this way there is less danger of perforation of the brain, for the level of the brain can be ascertained from the roof of the frontal sinus. When the pus from the ethmoid cells has perforated the lamina papyracea or os planum and discharges into the orbit it is usual to enter the ethmoid cells by an incision made through the upper lid. By this means a ready entrance is gained into the posterior ethmoidal cells, and free drainage may afterward be established through the nose.

The ethmoid cells may occasionally be reached through the antrum. The lower and external part of the ethmoidal cells lie in relation with the antrum, and in making a counter-opening from the antrum into the middle meatus of the nose behind the processus uncinatus these cells are often wounded. They may be purposely curetted if they are diseased.

Complications of Ethmoid Operations.

The diseases of the ethmoid cells are among the most tedious which the rhinologist will encounter. Sometimes the cases continue to discharge pus despite the greatest skill which may be directed toward removing the foci of inflammation, but in many other cases the results are brilliant and in almost all cases the patients experience great relief from their distressing symptoms.

There can be no doubt that these ethmoidal operations are justifiable, even though they are dangerous. Much of the results of treatment depend upon the care of the case after it has been operated upon.

Immediately after an ethmoid operation the patient may develop an emphysema of the upper eyelid as soon as he makes an attempt to blow his nose. This distressing accident is the result of an opening between the orbital and the ethmoidal cells. This opening may have been made by the instrument or it may have existed before and not have allowed the entrance of air into the orbit until the cells were destroyed. As soon as the patient blows the nose, air is pressed from the nose through the orbital plate into the loose, cellular tissue of the orbit and the upper lid. This is evidenced by a sharp pain, immediate swelling, and discoloration of the lid, and a characteristic crepitus which is felt as soon as the lid is touched. If these patients are placed in bed and cold compresses applied constantly over the eye, the emphysema will disappear in the course of two or three days without the development of any further complications.

ABSCESS OF THE ORBIT.

If a perforation of the orbital plate has taken place at the time of the operation, the patient, beside developing an emphysema of the lid, may blow some septic material from the field of operation into the orbit and from this an abscess may follow. It should be treated on general surgical principles by incision and drainage, as described on page 99.

PACHYMENINGITIS.

If the brain-plate has been wounded, or septic material has been conveyed to the dura mater, the patient may slowly develop a pachymeningitis. This disease is indicated by the development of headache, slowly increasing stupor, prostration, low

Fig. 31.—This specimen shows very clearly an example of an accessory ethmoid cell developed in the middle turbinate bone, a "cystic turbinate." The one on the right is large, on the left a smaller one is seen, partly due to the oblique line of section. On the right a stylus passed from the frontal sinus to the antrum shows an unobstructed channel, and illustrates how pus from a diseased frontal sinus may lodge in the antrum as a reservoir. The frontal sinuses are not shown.

temperature, and sometimes photophobia. Sometimes pachymeningitis will develop after an operation without the infection or exciting cause having come from the nose. It happens that cases of ethmoiditis often develop a low grade of pachymeningitis and are suffering from it at the same time when they present themselves for operation for the ethmoiditis. Sometimes the operating surgeon in opening the cells of such patients excites an irritation of the dura and a spread of the meningitis, although the instrument has not been outside the proper field of operation.

TREATMENT OF PACHYMENINGITIS.

These patients should be treated by rest in bed, purges, quiet, and the application of the ice coil to the head, and the administration internally of fluid extract of ergot and bromides. Sometimes leeches are useful if a number of them are placed on the forehead at the level of the base of the brain.

SEPSIS.

Sepsis and small venous thrombi may sometimes result from pieces of partially removed tissue which have undergone necrotic changes. In such cases the nose is to be cocainized and a search made for these foci of infection, and when they are detected they are to be curetted and cauterized.

AFTER-TREATMENT OF ETHMOID OPERATIONS.

For the first twenty-four hours after an ethmoid operation the patient should be kept in bed, not allowed to blow the nose, and the pledgets of sterile cotton should be removed from the nose as often as they become soiled. At the end of twenty-four hours, the nose should be sprayed with a 1 per cent. solution of cocain and afterward with a sterile saline solution. Some operators prefer to use a douche rather than a spray. If the douche

is used, care must be taken to prevent the irrigating solution from entering the Eustachian tube. After the irrigation has been performed, the nose should be inspected, and any loose pieces of membrane or blood clots which remain should be removed with the forceps. If there is no bleeding the nose should be dusted internally with an antiseptic powder containing iodoform or aristol, 10 or 20 grains of either, mixed with compound stearate of zinc or bismuth subnitrate as a vehicle (1 ounce).

If none of the complications have developed within twenty-four hours, the patient may be allowed out of bed and even out of doors. Sometimes in partial ethmoid operations it is not necessary to confine the patient to bed for the first twenty-four hours subsequent to operation.

The second dressing of the wound should take place at the end of forty-eight hours after the operation. The nose should be cocainized and cleansed as before, after which the surgeon should thoroughly clean out the operative field by means of cotton wound on applicators. By this time some granulation tissue will have begun to form, and if the foci of pus have not been entirely removed some pus will be found dripping from the infected granulations. It may be necessary to cut out some of this granulation tissue, or if there is not much pus it will suffice to lay a pledget of cotton soaked in an ichthyol solution against the operated field. A favorite application is as follows:—

℞ Ichthyol 3j
Menthol ..... gr. v
Orthochloro-phenol ..... *m*j
Glycerin ..... ℥j

If there is any tendency to necrosis, a pledget of cotton saturated in idodoform dissolved in ether—1 drachm to the ounce—should be laid against the necrotic area.

After the first forty-eight hours, the patient should be taught to cleanse the nostril with a douche or spray, and the operating surgeon should dress the case every day. It may now

Fig. 32.—A Frontal Sinus Having an Unusually Low Floor Extending Downward Below Base of Nasal Bones. The plain white string emerges from sinus to the nose at the level of the sinus floor.

be necessary to use a variety of medicaments, depending upon the conditions present, but the first principle of the after-treatment is to keep the drainage as perfect as possible and not to allow granulation tissue to spring up and fill in the region which has been operated on. Great care must be taken to prevent granulation tissue from springing up near the opening made into the cells, thus preventing the formation of a pocket of pus. For exuberant granulation, one uses gentle curettage, the application of a solid stick of nitrate of silver, or a solution of chlorid of zinc—50 grains to the ounce. If the discharge is abundant, it is good treatment to wipe out the discharging area with a solution of chlorid of zinc—2 grains to the ounce—or nitrate of silver, 10 grains to the ounce; but the best results in the after-treatment come from observing the source of any discharge which may be present and treating this local focus by curettage or cauterization.

Within a few weeks the discharge in most cases will practically cease, but sometimes an inconsiderable quantity of discharge will continue to form which prevents a perfect result. This requires constant treatment at home and in the office along the lines already suggested, and eventually this discharge will cease. No case of ethmoiditis should be considered cured until it has been free from discharge for three months.

CHAPTER IV.

THE MAXILLARY SINUS.

History.

Vaselius (1515) described the maxillary sinus, as well as the frontal and sphenoid sinuses, and asserted that they only contained air. From his time until the period of activity of Schneider (1661) various opinions were held about the antrum, some writers believing that it held air; others, that it produced mucus; some, that it was intended as a resonator for the voice; and a very frequent belief was that these cavities had to do with the elimination of the animal spirits. Morgagni (1783) thought that the sinuses were cavities which secreted impurities from the blood and held them. Nathaniel Highmore (1651) described this sinus, which since that time has borne his name—the maxillary sinus to-day being known as the antrum of Highmore. He published the history of a case of suppurative disease of the cavity. Velpeau, Molinetti, Mabonius, and Zwingler were all men who operated on the antrum of Highmore in those days of imperfect knowledge. William Cowper (1717), Lamorries (1717), and Jourdain (1765) operated on these sinuses and established rules of surgical procedure. Van Ruysch (1791) and Plaignand (1784) described tumors of the antrum of Highmore. More recently diseases of this cavity have received some attention from the hands of the dental fraternity, but these interesting cases are now turned into the field of nasal surgery, to which they properly belong.

Development.

The antrum of Highmore is present in the superior maxillary bone of the newly-born infant as a long slit-like cavity. It

Fig. 33.—This section shows the relationship of the anterior ethmoid cells and the flow of the frontal sinus. There is here a huge development of posterior ethmoid cells. Note the curving sweep of the sphenoethmoidal sulcus, backward to the naso-pharynx. The sphenoidal sinus is repeatedly divided by partial septa and bears a strong resemblance to the ethmoid mass in this respect.

very rapidly increases in size and at the end of the first dentition measures about a cubic centimeter. From then on until adult life it increases in size, and is usually the largest of the accessory cavities of the nose. It is never absent. It develops similarly to the frontal sinus from a bud of mucous membrane, which presses into the unossified structure of the superior maxillary bone, leaving the nose at the point which we have already identified as the antral opening—that is, at the posterior end of the hiatus semilunaris. The end of this bud, expanding and enlarging, presses its way through the structures of the maxillary bone, and by a process of absorption and internal development forms a cavity within the bony substance. The development proceeds downward, forward, backward, and outward, but not very much toward the orbit or inward. This leaves the original opening from the antrum at the upper and inner angle of the sinus in a place poorly arranged for drainage. In some cases the antrum is small. Under such circumstances it generally lacks development forward, toward the cheek, and downward toward the alveolar ridge. In other cases, the antrum is unusually large. This extra size of the antrum is obtained at the expense of the encroaching thickness of the alveolar ridge and the cancellous tissue of the palatal process of the superior maxillary bone.

Anatomy of the Maxillary Sinus (Antrum of Highmore).

The antrum of Highmore is a pyramidal cavity lying entirely within the superior maxillary bone. On each side the base of the sinus corresponds to the external nasal wall and lies partly opposite the inferior meatus and partly opposite the middle meatus of the nose. The base is crossed about its middle by the inferior turbinate body so that if a cadaver specimen is held with the light on its nasal side, the investigator looking into the antrum, the base or inner wall of the antrum will show a light

spot at its lower part, corresponding to the inferior meatus of the nose; above this is seen a shadow cast by the inferior turbinate body as it crosses this wall; while above the shadow another luminous spot will be seen which marks the point of the antrum lying opposite the middle meatus of the nose. The apex of the antrum is directed outward against the malar bone and generally extends as far as the articulation of this bone with the superior maxillary. The antrum presents for examination an upper, anterior, posterior, and inner wall, and a floor, which corresponds to the alveolar process.

THE ANTRUM ROOF.

The upper wall of the antrum is the floor of the orbit. This surface consists of two laminæ of compact bone separated about the middle to allow the passage of the infra-orbital nerve. The course of the foramen for the infra-orbital nerve is along the roof of the antrum and about its middle. The nerve emerges from the foramen upon the anterior surface of the antrum. In its course over the antrum roof, the nerve is separated from the antral mucous membrane by the periosteum of the antrum and a thin layer of bone, scarcely a half millimeter in thickness. This relation is important, for in operative work upon the antrum it is easy to excite a neuralgia or neuritis of the inferior orbital nerve. Disease of the antrum frequently causes chronic neuralgia of this nerve.

THE POSTERIOR SURFACE.

The posterior surface of the antrum is a large, rounded, roughened surface, which serves for the attachment of muscles and forms the anterior wall of the spheno-maxillary fossa. It is of no importance except as it serves for the attachment of the muscles. Behind this lies the internal maxillary artery. These parts are never approached in operations.

Fig. 34.—1, Accessory anterior ethmoid cells developed in the processus uncinatus and the bone in front of this structure. 2, Ethmoid cells, the lower enveloped in the bulla ethmoidalis. 3, Posterior ethmoid cells. 4, Sphenoidal sinus. 5, A tube in the hiatus semilunaris. 6, Inferior turbinal body. Note the great size of the processus uncinatus—usually a narrow, thin ledge of bone. Here it is very cellular.

Fig. 35.—1, Naso-frontal duct, looking from behind. 2, Ethmoid cell to the inside of duct in turbinate. 3, Processus uncinatus.

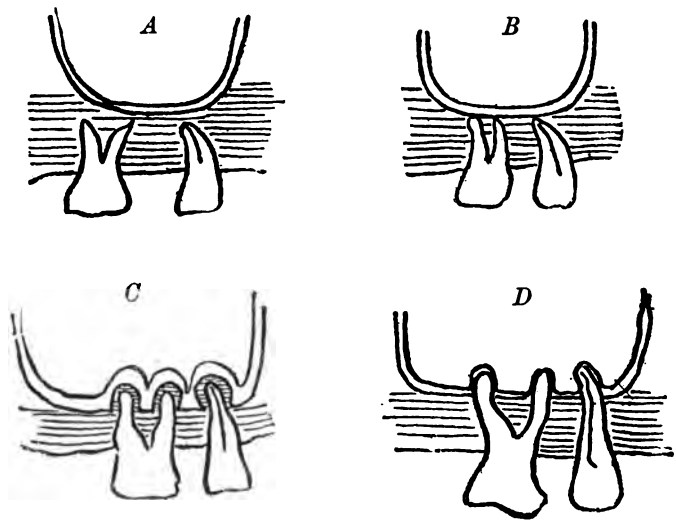
THE ANTERIOR SURFACE.

The anterior surface of the antrum is an important part from a surgical standpoint, since it is through this surface that we most often reach the antrum. The anterior surface is bounded above by the infra-orbital ridge; internally by the free surface of the nose; below, by the alveolar process; and externally, by the malar ridge. This is a strong and always well-developed prominence of bone which extends from below upward and outward and separates the anterior from the posterior surface of the antrum. The anterior surface of the antrum contains in its upper part the infra-orbital foramen, below which there is a fossa generally of considerable size—the canine fossa. When the canine fossa is well developed it marks the thinnest part of the antrum wall and can readily be felt in the living subject as a pit just behind and above the root of the canine tooth.

THE FLOOR OF THE ANTRUM.

The inferior surface or floor of the antrum is bounded by the alveolar ridge. The alveolar ridge contains the roots of the teeth. If specimens are examined a variation will be found in the relation of certain teeth to the floor of the antrum. The incisors and the canine teeth, and the first bicuspid, will have no relation with the antrum floor, but the second bicuspid and the first molar will be found to have a most intimate relation with the floor of the antrum. Sometimes the second molar will also have an intimate relation with the posterior part of the antrum. Usually the roots of the second bicuspid and of the first molar will be found approaching the floor of the antrum and separated from it only by a thin partition of cancellous bone of the alveolar process. In such a case the periosteum of the root of the tooth will be separated from the mucous membrane of the antrum by the cancellous bony partition and the periosteum of the antrum

floor. In other cases the roots of the second bicuspid and first molar will project into the floor of the antrum in such a way as to indent this floor and make a decided protuberance in the floor of the antrum. In these cases, the root of the tooth will be sepa-



Diagams Showing the Varying Relations of the Second Bicuspid and First Molar Teeth to the Floor of the Antrum. *A*, Normal relation—some bony wall between the root ends and the antrum floor. *B*, Tooth roots closely approach the antrum floor. *C*, Tooth roots bulging upward in floor, but still separated from the mucous membrane lining of the antrum by a layer of bone. *D*, Roots in antrum—covered only by the mucous membrane lining the cavity.

rated from the mucous membrane of the antrum only by the thin lamina of compact bone which forms the floor of the antrum. In still other cases the roots of the second bicuspid and first molar will perforate this lamina of bone and project through the antrum floor into the antral cavity. In such cases the root of the tooth lies in direct contact with the mucous membrane of the antrum. (See cuts showing variations of relation of teeth to the floor of the antrum.)

From the study of the relation of the teeth to the antrum, it will be seen plainly that the antrum can best be reached through the root cavity of the second bicuspid.

THE INNER WALL OF THE ANTRUM.

The inner wall of the antrum is also the external nasal wall.

This wall must therefore be described from both sides—the antral and the nasal sides. Seen from the antral side, the internal wall or base of the antrum presents anteriorly, running from its upper and anterior angle, a considerable protuberance extending downward and backward which marks the course of the lacrymal duct. This protuberance is always of considerable size and can readily be recognized with the finger during antrum operations. At the junction between the upper and inner wall, about half an inch behind the protuberance of the lacrymal duct the antral opening may always be found. This antral opening is opposite the middle meatus of the nose and is continuous on the nasal side with the posterior end of the hiatus semilunaris. Behind the antral opening a very thin membranous, or sometimes ossified, area may be seen—the thinnest place in the antral wall.

From the nasal side the inner surface of the antrum presents a very different appearance if the opening is seen in a disarticulated superior maxillary bone or in a cadaver specimen with the soft tissue attached. In the skeleton specimen this part is composed of a rather thick wall of bone which is deficient at its upper and middle part, so as to form a large heart-shaped opening from the antrum into the nose.

In the cadaver specimen, however, the picture is an entirely different one. The whole of this space is closed except for the small antral opening at the posterior end of the hiatus semilunaris. The differences between these two openings is accounted for by the filling up of this large heart-shaped space which occurs in the skeleton specimen by certain structures which must now be described.

In a skeleton specimen it will be noticed that in front and behind this heart-shaped prominence there is a ridge which serves for the attachment of the inferior turbinate body. The inferior turbinate body therefore crosses the lower part of this space, and opposite the opening in the superior maxillary bone it sends a process or flange of bone downward which fills in the lower third of this heart-shaped opening. This process of bone is known as the antral process of the inferior turbinate body. It also sends a narrower and thinner process or flange of bone upward so as to also partly fill in the space above the inferior turbinate body. This second process of bone is known as the processus uncinatus of the inferior turbinate. At its upper edge this process articulates with the processus uncinatus of the ethmoid bone, which projects downward and backward from the anterior end of the ethmoid bone. As it does so it covers this heart-shaped space of the antrum, and articulating with the processus uncinatus of the inferior turbinate body it divides the remainder of this heart-shaped space into an anterior and a posterior part.

The space in front of the processus uncinatus is closed by a fibrous membrane which stretches from the edge of bone to the processus uncinatus. The part left open behind the processus is completely closed, except at the lower end of the processus uncinatus, by a membrane which stretches from the bulla ethmoidalis and the posterior edge of the bony heart-shaped opening forward to the edge of the processus uncinatus. This membrane does not stretch directly forward, but as it approaches the processus uncinatus it bulges forward and outward in such a way as to leave a space between the bulla ethmoidalis and the processus uncinatus which we know as the hiatus semilunaris. As it continues in its course around the outer surface of the processus uncinatus, it makes a still larger groove which is known as the infundibulum. It finally attaches itself to the

Fig. 36.—The frontal sinuses shown here are seen to drain to the eye side of the middle turbinal body, *i.e.*, into the hiatus semilunaris in the middle meatus of the nose. Ethmoid cells are seen on either side next the orbit. Below the orbit is the antrum, and the inferior turbinate bone crosses the middle of the nasal wall of this cavity.

posterior edge of the processus uncinatus and completely closes in the remainder of this space except where it is absent below to form the antral opening.

The lower third of the internal antral wall is opposite the inferior meatus of the nose. In it is found, one inch behind the anterior end of the inferior turbinate body, a thin plate of bone formerly described as the antral process of the inferior turbinate body. By perforating this thin plate of bone with a hollow needle, it is possible to wash out the antrum. In fact, this marks the best site for perforation of the antrum. The middle third of the inner wall is opposite the inferior turbinate body; the upper third of this surface is opposite the middle meatus of the nose and always contains the normal opening of the antrum. Behind it is the membranous part of the antrum wall, a convenient place for counter-openings in antral operations.

VARIATIONS IN SIZE AND SHAPE OF ANTRUM.

While the antrum is invariably present, there is a considerable variation in its size and consequently in its position. The greatest variation is seen in its relation to the nasal wall and the alveolar process. I have never been able to determine any regular relation between the size of the antrum and the size of the skull. There are large skulled people who have small antra, and people with small skulls who have large antra. The size of the other accessory cavities gives no indication of the probable size of the antra. An average sized antrum has a capacity of about ½ ounce, but some antra do not hold more than 2 drachms, while others hold nearly 2 ounces.

Variations in the size of the antrum may occur from deviations from the normal obliquity of any of its walls, but this applies particularly to the nasal wall and the floor. If the orbit

is very large, the antrum may be correspondingly decreased in size by the concavity of the floor of the orbit.

In one case I have seen the cavity of the antrum greatly narrowed by a curious guttering of the floor of the orbit into the antrum. This was marked enough to give one the impression that a periosteal tumor had formed on the antrum roof.

There is not much variation in the posterior wall of the antrum, which is generally wide and well developed. If the floor of the antrum is much higher than the nasal floor it is possible that the canine fossæ may not come into relation with the floor of the antrum at all, but may lie opposite the inferior meatus of the nose. This is especially true if, in an antrum whose floor is unusually high, the inner wall of the antrum is, further, very concave.

VARIATIONS OF THE FLOOR.—There is the greatest variation in the level of the floor of the antrum. Normally described, the floor of the antrum may be said to be on a level with the floor of the nose, but it very frequently is lower than the nasal floor. In this case, the antrum floor is very apt to be wide, and very little cancellous tissue intervenes between the root of the second bicuspid, the first molar, and the floor of the antrum. Sometimes the antrum floor is very low and bulging and includes a part of the oral surface of the palatal process.

In other cases the antrum floor, instead of being on a level with the nasal floor, is considerably above it.

Such antra are small, and a considerable quantity of cancellous tissue intervenes between the roots of the teeth and the floor of the antrum. This makes the antrum difficult to approach through the cavity at the roots of the teeth, and it is also in these cases that the canine fossa relation varies, so that if an attempt is made to enter through the canine fossa the nose instead of the antrum may be invaded.

VARIATIONS OF THE INNER WALL.—This wall is subject to considerable variations. The wall may be slightly oblique,

Fig. 37.—Actual Size of Maxillary Antrum in New-born.

Fig. 38.—1, Dental Cyst.

Fig. 39.—Inferior Turbinated Bone, Showing Its Entity as a Separate Structure. The thin finger-nail-like piece in the center fits into the gap at the lower part of the nasal wall of the antrum of Highmore. It is very thin and puncture is easily made through this—and this only—into the antrum from the inferior meatus. The little prominence above is the processus uncinatus of the inferior turbinate and unites with a like named process from the ethmoid bone.

Fig. 40.—1, The Antral Process of the Inferior Turbinate seen on Posterior View.

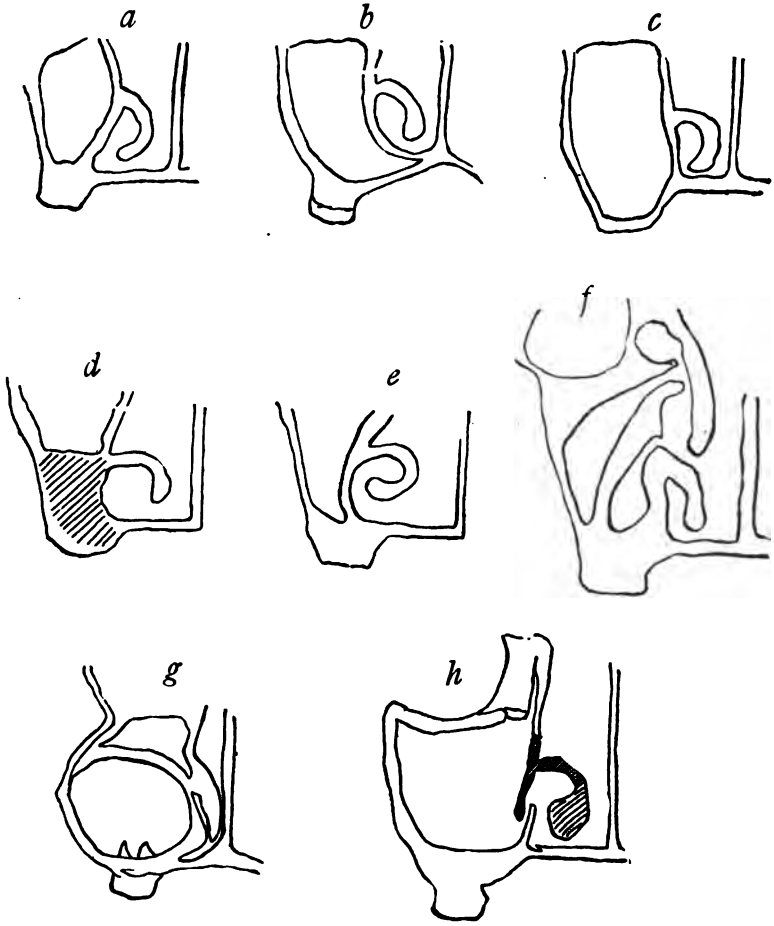


Fig. 41.—Diagrams Showing the Varieties in the Relations of the Antrum with Neighboring Structures. *a*, Normal. The good sized cavity of the antrum, the center of its inner wall crossed by the inferior turbinate bone. *b*, Antrum, large and encroaching on the floor of the nose, as well as on the alveolar boundary. *c*, Marked development downward in the alveolar boundary. *d*, Antrum well-developed above, but not downward. The inferior turbinate bone is below the floor instead of across the center, as in *a*. *e*, Inferior nasal meatus encroaching on the antrum. Note the ease with which the nose can be entered instead of the antrum through the canine fossa in such a case. *f*, Development of two separate cavities, each with an opening into the nose. *g*, Large dental cyst. Its bulging inner wall pressing the inferior turbinal against the septum. Roots of a molar tooth showing through the floor. *h*, Shows the part played by the inferior turbinate bone in building the nasal wall of the antrum. The uncinate process above joins with the uncinate process of the ethmoid bone. The antral process below is the part through which the puncture is made for diagnosis or washing out the antrum for treatment.

which may be considered normal; in other cases it may be very convex, curving into the antrum and materially lessening the width of this cavity.

VARIATIONS IN THE APEX.—The apex of the antrum ordinarily extends out nearly as far as the articulation of the malar bone with the superior maxillary bone. Sometimes the antrum may extend outward so as to indent the malar bone, a part of its cavity being within this bone. In all such cases the malar bone does not form any part of the antrum wall, but the superior maxillary wall is shoved outward into the malar bone. In the same way the ethmoid cells are sometimes forced upward into the frontal sinus.

OPENINGS AND ACCESSORY OPENINGS.

The normal opening of the antrum of Highmore communicates with the nose through the middle meatus and is always to be found at the posterior end of the hiatus semilunaris, just behind the processus uncinatus. The direction of the antral opening from the nose into the antrum is downward, very much forward, and outward. This opening is always present, and so far as I know is never closed except pathologically. The antrum opening is entirely hidden by the middle turbinate body, and for this reason is inaccessible to probes and cannula. In cases where the middle turbinate has been removed or where it is much atrophied, it is possible to probe the antral opening, but I am convinced that it is rarely possible to wash out the antrum through the antrum opening with a cannula. The angle which the antrum opening makes with the nose is so acute that a cannula properly shaped would be too wide to allow free movement within the nose, and under all circumstances the most we can hope for from such a cannula would be that it might barely enter the nasal end of the antrum opening; but in no case do I believe that the cannula can be so curved that it will pass through the

antral opening and lie with its free end within the antrum. It is undoubtedly a fact, however, that the antrum is often washed out through the middle meatus, but it is my belief that this always occurs through *the accessory antrum openings,* never through the normal antrum opening. These accessory antrum openings are quite frequently found, and are always located in the membranous portion of the nasal wall behind and below the normal opening of the antrum. This membranous wall is often defective, and the accessory openings are sometimes larger than the normal opening. The accessory antrum openings occur in about 50 per cent. of the cases. A variety of these accessory openings are seen in the cuts below.

THE RELATION OF THE LACRYMAL DUCT.

If the inner wall of the antrum is seen from the antral side, a large convex protuberance of bone will be seen extending from the anterior superior angle of the antrum obliquely downward and backward to a point opposite the middle of the antrum near its floor. This protuberance marks the course of the lacrymal duct. It is always an important landmark and can readily be felt with the finger in antrum operations. The importance of this relation is perceived in antrum operations, when it becomes a question of making a counter-opening. If counter-openings are made in the region of this protuberance, the lacrymal duct will be wounded and subsequent stenosis of the duct will take place. Counter-openings should always be made behind this protuberance at the upper and posterior angle of the antrum. Just behind this protuberance for the lacrymal duct is always to be found the normal opening of the antrum, and behind this a considerable membranous area, which has been described in detail on page 117.

It is in this region that counter-openings may be safely made without danger of wounding the lacrymal duct.

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Fig. 42.—This section shows the nasal septum and on its right the middle turbinate. Next to this, above, is seen the blind pouch in which one division of the hiatus semilunaris ends above. The other branch drains the frontal sinus into the middle meatus of the nose. A good example of ethmoid cell development is shown next the orbit. The nasal septum is slightly thickened at the usual situation of such an abnormality. The antrum and inferior turbinal are seen below.

Explorations of the Antrum.

Instrumental investigation of the antral cavity, which means the washing out of the cavity either through the normal or accessory openings of the antrum, or through perforations made in its wall, is a valuable method of diagnosis.

EXPLORATIONS THROUGH NORMAL OPENING.

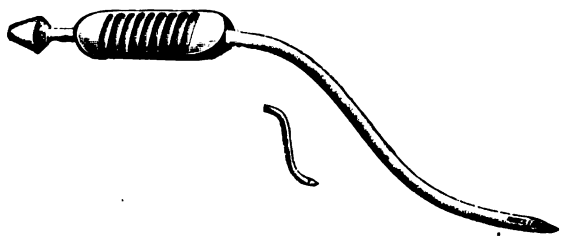
The most difficult method of exploration is through the normal opening. As mentioned above, washing the antrum through the normal opening is an impossibility except in cases of atrophy. If accessory openings are present the irrigation of the antrum is rendered possible. A silver cannula having a sharp half-inch curve, bent at an angle of 45°, is introduced into the nose after cocainization, usually after removal of the anterior end of the middle turbinate body. The end of the cannula should pass over the top of the inferior turbinate body until it hooks against the posterior end of the processus uncinatus.

It should then be shoved .5 centimeter backward and turned outward toward the lateral nasal wall. By slight moving in this position, if an accessory opening is present, the end of the cannula will slip into it. Generally the cannula will remain fixed in this position. An irrigating syringe with a rubber tube is attached to the free end of the cannula. The antrum is then irrigated, the water returning through the antral opening. The head should be tipped forward to prevent the liquid from entering the pharynx. The return liquid is received in a pus basin held under the patient's chin and may then be studied at leisure.

PUNCTURE THROUGH THE INFERIOR MEATUS.

The best method of exploring the antrum is by puncture with a perforating cannula through the inferior meatus. To perform this slight operation, a bit of cotton soaked in a 4 per

cent. solution of cocain should be introduced between the nasal wall and the inferior turbinate body. After four minutes the parts are ready for perforation. A double curved irrigating cannula, with a sharp point (see cut below), is now introduced into the inferior meatus of the nose, between the inferior turbinate body and the external nasal wall. It is then guided backward until its point is one inch from the anterior tip of the inferior turbinate body. This brings the point of the cannula behind the opening of the lacrymal duct, and if the point of the cannula is now carried forcibly upward and outward so as to



Author's Antrum Irrigator.

reach the angle made by the junction of the inferior turbinate, it will in this locality (one inch from the anterior end of the turbinate body), if turned outward, perforate the thinnest part of the antral wall—that is, the antral process of the inferior turbinate body. (See Figs. 39 and 40.) Very slight pressure of the needle against the nasal wall is necessary to drive it through this thin wall into the antrum, particularly if the operator has placed the needle in exactly the right position.

If much difficulty is experienced in perforating the antral wall, then the needle has not reached the thin plate of bone; it must then be withdrawn and reintroduced. The perforating needle slips into the antrum with the unmistakable sensation of having entered a cavity.

The patient's head should now be bent forward. An irrigating syringe is attached to the perforating hollow needle and

Fig. 43.—On the right side the frontal sinus is clearly seen to drain into the middle meatus. The section is too oblique to show it as well on the left side. Ethmoid cells in the lateral masses of this bone are seen on each side next the orbit. Note the straight nasal septum and the pronounced deflection of the septum between the two frontal sinuses. The antrum of Highmore and inferior turbinals are seen below.

Fig. 44.—Shows a small frontal sinus and a large anterior ethmoid cell crowding into its floor. There is cellular development of the upper part of the processus uncinatus, a well-marked meatus semilunaris, a small bulla ethmoidalis, large posterior ethmoid cells and a small sphenoidal sinus. Note the almost horizontal position of the large posterior ethmoid sulcus pictured here, also the well-marked accessory antrum opening below the end of the processus uncinatus. The inferior turbinal is normal.

the antral cavity is washed out. The flow returns through the normal antral opening and is received in a pus basin held beneath the patient's chin. The washed out contents of the antrum may be studied at leisure.

PERFORATION THROUGH THE CANINE FOSSA.

Perforation through the canine fossa is now an obsolete method. It may sometimes be necessary to use it, but I would reserve the use of this method to those cases where the nose is entirely blocked up with a growth. The region of the canine fossa is cocainized when ready for perforation, the lip is turned up, the canine fossa found. A small incision is made over the region to expose the bone and a hand drill is used to enter the antrum. The end of the drill should enter the antrum at an angle of 45°, and care should be taken not to direct the end of the drill inward, for fear of entering the nose instead of the antrum.

PERFORATION THROUGH THE ALVEOLAR PROCESS.

If the second bicuspid or the first molar is absent on the suspected side, it is justifiable, if one expects to do an alveolar process operation, to explore the antrum through the root cavity of either of these teeth. The alveolar process is cocainized first with a 4 per cent. solution of cocain, applied on cotton and afterward by injection of a ½ per cent. solution into the alveolar mucous membrane. A small crucial incision is made over the region of the root cavities of the second bicuspid or first molar, and a hand drill is used to perforate the alveolar process by slowly working it upward, with the end of the drill pointing perpendicularly upward. Ordinarily the antrum is quickly entered. After the bleeding has ceased an irrigation cannula may be introduced through the drill opening and the antrum washed

out. The flow generally returns partly through the nose, through the antral opening, and partly through the opening in the alveolar process. After this operation it is necessary to plug the opening with a piece of gauze to prevent infection from the mouth.

Surgical Treatment of the Maxillary Sinus.

The surgical treatment of the maxillary sinus may be either conservative or radical. The conservative method consists in washing out the antrum through the normal opening or by puncture. These methods have been fully described above, under exploration of the antrum.

The radical, or operative procedure, may be described as first, an operation through the alveolar process; second, through the anterior wall; third, through the inferior meatus; fourth, through the membranous portion behind the hiatus semilunaris.

The Alveolar Operation, Anæsthetization by Cocain or Ether.

To enter the antrum in this operation, the root cavities of the second bicuspid or first molar teeth are chosen. If the teeth are present, one is withdrawn. If the teeth are absent, a crucial incision is made over the inferior surface of the alveolar process, and a periosteotome is used to separate the alveolar mucous membrane and the periosteum from the bony process. When the alveolar process is exposed, either a hand drill or a dental drill is used to perforate through the alveolar process into the antrum. *In every case the end of the drill must point toward the supra-orbital nerve.* This is an important rule, for a slight deflection toward the median line may send the drill into the nose, and an equally slight deflection externally will send it into the muscles of the cheek.

Fig. 45.—Shows the external nose from the right side. The cheek has been cut away and we are looking at, 1, The nasal wall of the antrum from the antral side. 2, Normal opening of the antrum into the nose. 3 and 4, Opened ethmoid cells. 5, Sphenoidal sinus. 6, Orbital plate of the ethmoid, also called "the lamina papyracea." 7, Frontal sinus. 8, Opening into lacrymal duct—partly exposed lower down.

Fig. 46.—"Cystic" Middle Turbinates, *t.e.*, Accessory Ethmoid Cells, Enveloped in These Bones. The one in the left is quite large. The antra are well shown—a few ethmoid cells next the orbits. The nasal septum is straight. The crista galli is shown above. In the antrum to the left is seen a partial septum coming from the floor.

As soon as the antrum has been entered, all resistance at the end of the drill ceases. Care must be taken not to introduce the end of the drill far enough to wound the roof of the antrum. When this opening has been made, it is necessary for the operating surgeon to orient himself. A probe should now be introduced through this opening, and another probe should be introduced into the inferior meatus of the nose. If the probe which is supposed to be in the antrum does not come in contact with the probe introduced into the nose, it is positive proof that the drill has not entered the nose instead of the antrum. If now the probe defines externally a bony wall, it is proof that the drill has not entered the cheek. It can therefore by exclusion certainly be said to have entered the antrum.

While these points are being identified, any discharge which comes through the opening should be collected for inspection. Ordinarily, if the antrum is diseased, pus and *débris* of mucous membrane will immediately run from the antrum.

The size of the antrum should now be ascertained with a probe, and measurements taken from the opening which has been made, upward toward the roof; forward, to the anterior angle; inward, to the nasal wall, and backward to the posterior wall. In this way the operator is able to judge exactly of the size of the antrum, and at the same time to receive some information of its contents. The drill opening is generally not large enough to attempt a curettement. The opening is therefore enlarged by means of a larger drill or by carefully chiseling away the surrounding alveolar process. If the teeth are present, generally the entire space between two teeth is removed. Care should be taken not to remove the palatal or oral side of the alveolar process, for if this is done it may seriously interfere with proper adjustment of a tooth plate. In this way the opening is generally made .5 centimeter square. Curettes should now be used within the antrum if it has been found to be diseased; the operator may either curette the antrum superficially

or may make an attempt with curettes bent at various angles to remove the entire mucous membrane. This is not possible in the alveolar process operation, and great difficulty will be experienced in removing the mucous membrane from the inner wall, particularly from the upper and inner angle. It is also difficult to remove the membrane from the anterior angle. Considerable bleeding will occur while the membrane is being curetted. This may be checked by washing out the antrum with peroxide of hydrogen, or by the introduction of strips of gauze which have been soaked in peroxide of hydrogen and subsequently wrung nearly dry.

After the mucous membrane has been loosened, the antrum should be washed out with a warm boric acid solution, and care should be taken that the nasal opening is not blocked with clots of blood or pieces of the lining membrane of the antrum. The curetting should be continued until no more mucous membrane can be felt. After each curettage, great care should be taken to remove the products of the scraping, for if any of these are left behind they undergo decomposition and set up sepsis.

After the antrum has been satisfactorily scraped and washed, it should be firmly packed with narrow strips of sterile gauze or iodoform gauze. In packing the antrum the upper posterior part should be packed first, until the posterior half of the antrum is entirely filled. The anterior part should then be tightly packed. A careful count must be made of the number of strips introduced within the antrum, so that in redressing the wound all the gauze may be removed. Great care must be taken to keep the alveolar opening tightly packed so that it will not close.

AFTER-TREATMENT.

The antrum should be dressed about every third day. The packing should be removed and the antrum irrigated with a normal salt solution, or a saturated solution of boric acid. After a

Fig. 47.—Shows a moderately sized frontal sinus, with an ethmoid cell bulging forward into its floor. A large series of ethmoid cells, and a small sphenoidal sinus. A round accessory opening into the antrum is seen below. The middle turbinate has been removed, but the inferior is in place.

week or ten days, the soreness of the alveolar process arising from the operation will have disappeared, and then the continued patency of the operative opening should be secured by the introduction of a plug of vulcanized rubber, made to exactly fit the surgical opening. This plug is fastened to a tooth plate which the patient may wear, or to a horizontal vulcanized flange which will fit the alveolar process and prevent the plug being lost within the antrum. This is the best method of preventing a re-infection of the antrum.

At the end of two weeks the gauze packing should be discontinued. The patient may be allowed to remove the vulcanite plug and irrigate the antrum as often as may be necessary. These alveolar openings sometimes cure chronic empyema of the antrum in six weeks, but generally require a longer time. When no discharge has been noticed for one month, the surgical opening may be slowly allowed to close by gradually diminishing the length and thickness of the vulcanite plug.

Radical Alveolar Process Operation.

By this term is meant an operation by which as large a space as possible is made through the root cavities of the teeth. It is an operation not often performed, and has been rendered obsolete from the decided advantages of the operation through the anterior wall. The technique of this operation is similar to that described above under the "Alveolar Operation," except that the entire bony alveolar process between the posterior surface of the first bicuspid and the anterior surface of the second molar is chiseled out. The antrum is first found by boring a drill hole through the alveolar process in the region of the second bicuspid root cavity; and from this as a starting point the bone chisel is used to remove the alveolar process, leaving the outer and inner surfaces. Care must be taken not to destroy the oral or palatal surface of the alveolar process, so as to interfere with

the subsequent fitting of a tooth-plate. A space of considerable size is thus made from the mouth to the antrum, large enough to admit curettes of considerable size, and to furnish drainage.

The objection to radical alveolar process operation is the danger of reinfection from the mouth, but this is considerably minimized if the opening into the antrum is closed by a well-fitting piece of vulcanite attached to the tooth-plate.

The other steps of the operation are similar to those of the ordinary alveolar process operation, and the results and the length of time of healing are about the same.

Operation Through the Inferior Meatus.

Some operators reach the antrum through the inferior meatus, but this method is open to criticism and objection from the fact that drainage is imperfect, that it is almost impossible to curette the antrum, and that granulation tissue springs up from the floor of the nose in great abundance, so as to readily block the opening made into the antrum. If it is decided to perform this operation ether narcosis is used, and a large piece of the anterior end of the inferior turbinate body is removed, so as to afford a view of the inferior meatus.

A probe should now be introduced into the inferior meatus in such a way that it will enter the nasal opening of the lacrymal duct, but care must be taken not to wound this duct. When the opening of the lacrymal duct is found, a chisel is placed behind this opening in the inferior meatus, and a few sharp strokes with the mallet will send the chisel into the antrum near its floor. After the antrum has been entered, the chiseling may be continued until an oval piece of bone has been removed, or the loosened pieces of bone may be removed with cutting instruments.

In this way an opening is made large enough to admit the little finger. The hæmorrhage is very profuse from the abun-

Fig. 48.—The Antrum of Highmore from the Outer or Malar Side. The large opening into the nose is not the normal opening at the end of the hiatus semilunaris, but an accessory opening due to the incomplete closure of the wall posterior to the bulla ethmoidalis. There are often several of these accessory openings. Below, the alveolar process has been partly cut away to show the relation of the teeth roots to the antrum floor. Note the close relation of the second bicuspid and the molars; also the distance separating the other teeth from the antrum. This is a normal specimen, so far as the teeth relations are concerned.

dant blood supply near the floor of the nose, and some delay may be experienced in the operation from this source.

An attempt should now be made to curette the antrum through the opening just made, but this effort will be imperfect, and a drainage tube either of metal or rubber is now introduced through the opening, the end of which projects from the nostril. In this operation the antrum is not packed.

AFTER-TREATMENT.

The drainage tube is removed at each dressing, its purpose being merely to prevent the antrum from closing. The antrum is washed out daily until pus has ceased to form. At the end of a week or ten days an attempt may be made to remove the drainage tube and then the operator will be forced to fight the granulation tissue which will constantly spring up and attempt to close the operative opening. This is combated by repeated curettage, by the application of caustic, and by dilatation.

OPERATION THROUGH THE ANTERIOR WALL OF THE ANTRUM.

This operation is superior to all the other operations, for it allows perfect exposure of the antrum interior and enables us to close the mouth wound at once while sufficient counter-openings may be made in suitable parts of the nasal wall to secure drainage. By means of this operation it is also possible to resect the infra-orbital nerve, as it runs over the roof of the antrum. It is also possible to remove tumors of the antrum.

OPERATION.

This operation may be performed under cocain anæsthesia, but ether is sometimes used. An incision is made at the junction of the buccal with the alveolar mucous membrane, extending from the median line posterior to the lower edge of the malar

prominence. It will be remembered that this malar prominence marks the posterior border of the anterior wall of the antrum.

The first incision should extend through the periosteum to the bone. A small periosteotome should now be used to separate the alveolar mucous membrane downward from the alveolar process and the buccal tissues upward. The buccal mucous membrane, muscles, and periosteum should be separated from the anterior wall of the antrum by carrying the periosteotome all around this anterior wall. As the operation progresses, the assistant with blunt retractors separates the bared surfaces and allows the operator a better view of the field. As the periosteotome separates the soft tissue from the anterior antral wall, a point will be reached where the bony margin of the nose will be seen internally, the infra-orbital nerve emerging from its foramen, will be seen above, while posteriorly the malar ridge will be plainly visible. (See cut.)

A small chisel should now be used and the antrum should be opened through the exposed anterior wall, 3 to 4 millimeters (⅛ inch) in front of the malar ridge. This point for opening the anterior wall is much safer than one through the canine fossa, which of course has been exposed. I have never seen an antrum which did not extend out as far as the malar ridge. This is the thinnest part of the wall of the antrum and a chisel enters it at once, and from this opening the remainder of the anterior wall may be chiseled away as far downward as the floor of the antrum, and as far toward the median line as the nasal wall, and upward to within 4 millimeters (⅛ inch) of the infra-orbital foramen. A chisel or bone-cutting forceps may be used to perform this work. Care must be taken not to wound the infra-orbital nerve for fear of setting up neuritis or persistent neuralgia.

In this way the anterior wall is removed and a large opening made in the antrum. As soon as the mucous membrane lining the antrum is wounded, it bleeds profusely, but it is better to

Fig. 49.—This specimen shows finely, 1, The posterior ethmoid cell wall (superior turbinate). 2, Processus uncinatus of the ethmoid bone passing downward and backward to join the tip of (3) Processus uncinatus of the inferior turbinate. These form the front wall, and 4, The bulla ethmoidalis, forms the back wall of the groove or sulcus called the hiatus semilunaris. This last is pictured as a dark space here. Above 3 and in front of 2 are other dark spaces. These are the membrane-filled portions of this wall in which accessory openings into the antrum often occur because of incomplete closure with membrane. Under the inferior turbinate is 5, The lacrymal duct. 6, A good-sized frontal sinus. 7 and 8, Large ethmoid cells (anterior). They drain under the middle turbinal, which has been removed.

continue the removal of the anterior wall than to attempt to check the hæmorrhage. As soon as the anterior wall has been removed, the antrum may be packed with gauze wrung out of peroxide of hydrogen, which will stop the hæmorrhage.

Through the opening thus made the condition of the antrum is easily studied, and the contents of the antrum may be curetted much more easily than in any of the other operations. When this has been done (great care must be used to remove the mucous membrane from the angles of the antrum), the counter-openings should be made. For this purpose the operator studies the inner wall of the antrum. He notices the large convexity which marks the course of the lacrymal duct, and avoids this. Just behind this convexity, at the junction of the upper and inner wall he will find the normal opening of the antrum. The region behind this normal opening is largely membranous, or else very thin bone. (See description on page 117.) It is this point which he selects for a counter-opening. With a curved pair of scissors, or with a very sharp curette and cutting forceps, he should now cut away the membrane or thin bony plate behind the normal opening of the antrum, thus making an opening into the middle meatus of the nose, 1.5 centimeters in diameter. Before this opening is made the anterior end of the middle turbinate should be removed. The antrum is packed with one long strip of iodoform gauze, the end of which passes through the counter-opening into the middle meatus of the nose. When the antrum has been packed with gauze, the edges of the mouth incision are drawn together and secured with sutures.

AFTER-TREATMENT.

The gauze is removed at the end of three days by drawing it through the counter-opening into the nose, and the antrum is washed out through the counter-opening. This is always easily found with the curved cannula attached to a syringe, carried

over the inferior turbinate into the middle meatus. Just behind the processus uncinatus the counter-opening will always be found. Through this opening the antrum may be subsequently treated.

This operation gives the best results. The entire lining of the antrum may be removed, producing an immediate cessation of the pus formation. There is no danger of subsequent infection unless it should come through the nose. The mouth wound heals by primary intention and ceases to be an element of infection, and the irrigation of the antrum and the drainage therefrom are as perfect as can be wished. Many of these cases are cured in two weeks, though some require as long as six.

Fig. 50.—This specimen shows a fairly straight nasal septum. On either side the inferior and middle turbinals. Note how the middle turbinate bones are shown to be part of the ethmoid bone and that the ethmoid cells develop also in these structures. The inferior turbinates cross the middle of the nasal wall of the antrum on each side. Ethmoid cells are seen near the orbit on each side. The frontal sinuses are not opened. The cut shows their posterior or cerebral wall.

CHAPTER V.

SPHENOIDAL SINUS.

THE sphenoidal sinus developed within the body of the sphenoid bone occupies a part of the body and sometimes the lesser wings. There are two sphenoidal sinuses, one connected with each naris. The opening of the sphenoidal sinus into the nose is found near the nasal septum on the anterior wall of the sphenoidal sinus. This opening is in a depression of the nasal mucosa known as the spheno-ethmoidal sulcus, and is located just at the junction of the roof of the nose with the wall of the naso-pharynx. This places the sphenoidal opening entirely out of the line of vision the ethmoid cells and the middle turbinate obstructing the view. I have never seen a case of absence of the sphenoidal sinus, although there is the greatest variation in the size of the two sinuses.

RELATIONS OF SPHENOIDAL SINUS.

The sinus presents for examination a roof, a floor, an internal or septal wall, an external or brain wall, and an anterior wall. The roof of the sphenoidal sinus forms a part of the anterior cerebral fossa. The optic nerve and a part of the optic commissure generally lie upon the roof. If the sinus is of fair size, it may lie in relation with the pituitary body. The roof of the sinus is thin—ordinarily 2 or 3 millimeters in thickness.

THE EXTERNAL WALL.

The external or brain wall of the sinus has very important relations (see cut).

This wall of the sinus is extremely thin, scarcely a millimeter in thickness. Running along the upper part of this wall,

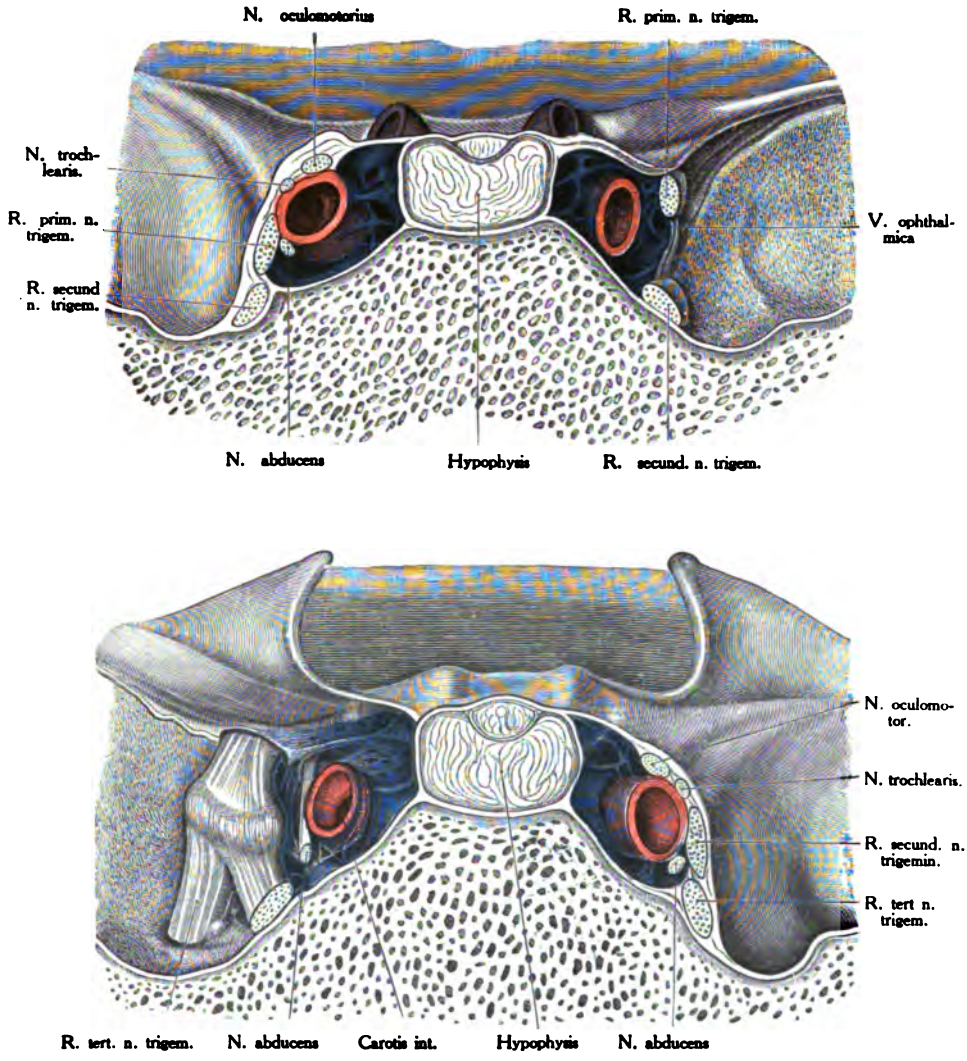
immediately next to the sinus, is the cavernous sinus of the brain —a large conduit for cerebral blood. Lying directly against the posterior and superior angle of the sphenoidal sinus wall is the internal carotid artery, and there is a groove in the external wall for the reception of this artery. Here the wall is extremely thin and there is great danger of puncturing the carotid artery in operations on the sphenoid sinus.

External to the cavernous sinus and the carotid artery lies the Gasserian ganglion of the fifth cranial nerve with its three main branches—the ophthalmic, infra-orbital, and inferior maxillary nerves. The fourth and sixth cranial nerves lie near the Gasserian ganglion, while the third cranial nerve perforates the cavernous sinus on the sphenoidal wall and runs through the cavernous sinus to the orbit. External to these structures is the dura.

The septum of the sphenoidal sinus is bony, more or less irregularly placed, and should be complete. It presents no interesting features for examination.

The floor of the sphenoidal sinus is formed by the body of the sphenoidal bone and in its upper part has a relation with the naso-pharynx. The wall is thick and is too resistant to allow operative interference.

The anterior wall of the sphenoidal sinus joins the floor at a very obtuse angle so that the demarcation between the anterior wall and the floor is not well defined. The anterior wall is divided into three parts—first, a narrow part next to the nasal septum which contains the opening of the sphenoid into the nose. This lies opposite the spheno-ethmoidal sulcus; a second broader part which butts against the posterior ethmoidal cell. This is known as the ethmoidal part of the anterior wall. Sometimes if the sinus is well developed externally, its wall may form a part of the orbit. The anterior wall of the sphenoid may therefore be described as being composed of three parts—one which lies adjacent to the nasal septum and contains the sphenoidal



Figs. 51 and 52.—Frontal Section Through the Sinus Cavernosus, showing Relations with the Cranial Nerves and Carotid Artery (Zuckerkandl Atlas).

opening (the pars nasalis); another, external to this lying in immediate relation to the posterior ethmoidal cell (the pars ethmoidalis); and external to this an extremely small area (pars orbitalis).

Accessory Sphenoidal Sinus.

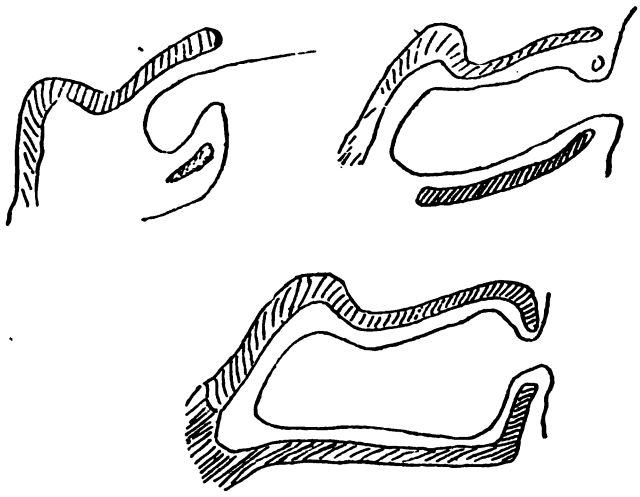
The accessory sphenoidal sinus is a cell developed within the lesser wing of the sphenoid. This wing of the sphenoid is often occupied by an air sinus. Sometimes the main sphenoidal cavity may extend outward and forward so as to occupy the whole or part of the lesser wing. At other times when the main sphenoidal sinus is small, the posterior ethmoid cell may extend far backward so as to occupy the lesser wing. An accessory sphenoidal cavity in the lesser wing, however, is developed either as an air space which communicates with the posterior ethmoidal cell and is lined with mucous membrane from that cell, or as a small cell not communicating with the main sphenoidal sinus or with the posterior ethmoidal sinus, but having an opening above and external to the usual sphenoidal opening in the spheno-ethmoidal sulcus. This is the true accessory sphenoidal sinus.

Probing the Sinus.

The opening of the sphenoidal sinus cannot be seen in a normal nose. If the ethmoid cells are very narrow, or if they have been destroyed by necrotic or atrophic processes, the opening of the sphenoid may be seen. It is to be looked for at the angle of junction between the nasal roof and the posterior wall of the naso-pharynx. In order to see the sphenoidal opening one should look between the septum and the middle turbinate body, glancing obliquely upward over the septal side of the middle turbinate body.

To probe the sinus a slightly curved probe should be passed to the roof of the nose against the nasal septum. It should then

be carried along the roof backward to a point where it begins to change its direction and passes downward along the posterior wall (the naso-pharynx). If the end of the probe is turned slightly outward just at the moment when it changes its direction from the roof of the nose and takes a course downward, it will often enter the sphenoidal sinus.



Development of Sphenoid Sinus.

VARIATIONS.

I have never seen an example of the absence of the sphenoidal sinus. Although there is the greatest variation in the size of the sinuses they are always present. The encroachment of a large sinus upon the area of a small one is generally at the expense of its posterior part. The relations of the anterior wall of the sinus do not vary greatly. This fact is of considerable importance in our surgical work. A sphenoidal sinus of fair size will hold about a drachm of liquid; a small sphenoidal sinus is one holding 10 minims; and a large sphenoidal sinus is one which will hold two drachms. The sphenoidal sinuses never

Fig. 53.—Right Frontal Sinus on Perpendicular Section—Partial Septum in Upper Third. Back of this are ethmoid cells and behind is a large sphenoidal sinus.

Fig. 54.—This section shows a posterior view of the sphenoidal sinuses. Note the septum dividing the space into a large right and a smaller left sinus. Smaller septa in each sinus redivide each side into partial sub-spaces. Note the resemblance to the ethmoid masses—in which, however, the cell division is more complete.

communicate with each other nor with the posterior ethmoidal cells, nor have they any accessory nasal openings. The usual opening of the sphenoidal sinus is in the spheno-ethmoidal fossa, as above described.

Development.

In early embryological life the sphenoidal sinus has no anterior wall. It is a pit or depression extending from the nose into the sphenoidal bone. Later in embryonic life the anterior wall which closes off the sinus is formed by the development of the posterior ethmoidal cell, which closes off the outer part, and still later on by the development of the Bertini cartilages which afterward become ossified and fill in the space between the posterior ethmoidal cell and the nasal septum. The sphenoidal opening which in the embryo occupies the whole of the anterior wall is by the development of the Bertini cartilage now narrowed to a small opening lying each side of the nasal septum. This opening persists and forms the normal sphenoidal opening. At birth the sphenoid cavity is tubular, at eleven months it is flask-shaped, after this it rapidly develops into a characteristic cuboidal cavity.

Irrigation of the Sphenoid.

When it is desired to irrigate the sphenoid sinus, as much of the middle turbinate as possible should be removed by the operation of turbinectomy previous to any attempt at washing out the sinus. A cannula slightly curved at its end and attached to a syringe should be used for the irrigation. To reach the sinus the cannula is introduced into the vestibule of the nose, carried to that point on the roof which is the cribriform plate, and then pushed along the roof of the nose horizontally until it begins to change its direction and turns slightly downward. At this point the cannula should be tilted outward, drawn a little

further downward, when it will slip into the sphenoidal opening. The sinus may then be irrigated.

Operations.

(a) To enlarge the normal sphenoidal opening.

When this opening is enlarged it should be done at the expense of its lower and outer edge, where the bone is thin. The operation of middle turbinectomy (see page 220) should be performed, and a strong sharp hook which will serve to enter and enlarge the opening should be introduced, the same as the cannula above described, and turned downward. In this rough way the normal opening of the sphenoid may be enlarged, although it will very soon close again by the formation of granulation tissue. Sometimes a bone curette may be used instead of a hook, but this is a dangerous procedure, for a strong curette may break through the sinus and wound the roof or external wall. After the sinus has been opened in this way it should be treated by irrigation.

(b) To open the sphenoidal sinus through the posterior ethmoidal cell.

A glance at the illustration (Fig. 25) will show that the best way to reach the sphenoidal sinus is through the posterior ethmoidal cell, for here at least two-thirds of the anterior wall is thin and lies against the posterior ethmoidal cell. This is not only the safer method of reaching the sphenoidal sinus, but it is the more rational one, since most cases of sphenoidal empyema are complicated by involvement of the ethmoidal cells, and the destruction of these cells is necessary to cure the suppuration.

If ethmoiditis complicates sphenoidal empyema, then the operation for ethmoiditis should be performed, as described on pages 92-96, until the posterior wall of the posterior ethmoidal

Fig. 55.—Posterior View of the Front or Nasal Wall of the Sphenoid Cavities. Note the openings, one for each cavity, on either side of the septum. Below is the nasal septum and the posterior nares. The wide rostrum of the vomer is well shown.

cell is reached. If the cutting forceps or the curette is now pushed backward through the posterior wall of the ethmoidal cell, it at once enters the sphenoidal sinus, into which a circular opening may be made at least a centimeter in diameter. This will supply all the necessary drainage from the sphenoidal sinus, while at the same time it provides for a cure of the ethmoidal suppuration. In some cases where the anterior ethmoidal cells are not involved in the suppuration, but the only diseased cavities are the sphenoidal sinus and the posterior ethmoidal cell, it is possible to open the posterior ethmoidal cell and from there to reach the sphenoid without destruction of the anterior ethmoidal cells. This may be done either through the nose or through the antrum of Highmore.

(c) OPENING THE SPHENOIDAL SINUS FROM THE POSTERIOR ETHMOID CELL AND FROM THE NOSE.

If performed through the nose, middle turbinectomy is a preliminary operation; then a strong hook having a cutting edge is introduced through the vestibule of the nose and carried upward and backward to the wall of the posterior ethmoidal cell —which it may be remembered is the wall known as the superior turbinate (see Fig. 6). The hook may be used to destroy the inner wall of the posterior ethmoidal cell and from there will perforate through the posterior wall into the sphenoidal sinus. There is danger in this operation of perforating the brain, arising from the fact that the operative field is out of the line of vision.

(d) TO OPEN THE SPHENOID SINUS VIA THE ANTRUM.

When the sphenoidal sinus is reached through the ethmoidal cell by way of the antrum of Highmore, this sinus is first opened by the destruction of its anterior wall, as has been previously described.

Then at the upper and inner angle of the antrum the posterior ethmoidal cell may be opened with the curette by continuing inward, backward, and upward. The sphenoidal sinus will be opened if the operator continues to curette in the same direction as if he were opening the posterior ethmoidal cell—that is, an angle of about 60°. The danger in opening the sphenoid by the posterior ethmoidal cell and the antrum route is considerable, for if the relations are not absolutely normal, or if the curette is introduced slightly external to the upper and inner angle of the antrum, instead of breaking into the posterior ethmoidal cell it will tear through the antrum wall into the spheno-palatine fossa, and the internal maxillary artery may be wounded. If the curette is used still more external to this, there is danger of perforation of the orbit.

Some writers have advised opening the sphenoidal sinus through the antrum of Highmore without entering the posterior ethmoidal cell, but this is to be mentioned only to be condemned. An examination of anatomical specimens shows that in about 3 per cent. of the cases the antrum and sphenoid lie in relation with each other at the posterior upper and inner angle of the antrum, but this occurs only when the sphenoid is abnormally large. In 97 per cent. of the cases this relation is not present, but the spheno-palatine fossa intervenes between the angle of the sphenoidal sinus and the antrum. This fossa contains the internal maxillary artery and the vidian nerve. A serious hæmorrhage would result if the artery were injured. It is justifiable to enter the sphenoid directly from the antrum only when a pathological sinus discharging pus is established from the sphenoid into the antrum.

After-treatment.

After opening the sphenoid it should be lightly packed with gauze for the first twenty-four hours. Then the packing should

Fig. 56.—This specimen shows clearly the back wall of the antrum on each side. Note the relation of the *upper*, *inner* and *posterior* angle of the antrum with the posterior ethmoid cells. Through this an entry can be made from the antrum into the posterior ethmoid cells and thence on into the sphenoidal sinus of the same side. This is the only way to reach the sphenoidal sinus from the antrum of Highmore. A large development of ethmoid cells is seen next the orbit—in the lateral masses of the ethmoid bone. The middle turbinate is shown to be part of the ethmoid bone. The inferior turbinate crosses the nasal wall of the antrum about the center of the cavity. Nasal septum is slightly deflected.

be removed and the subsequent treatment will consist of repeated irrigation through the artificial opening with a syringe and cannula. Gentle curettage of the sinus is justifiable, and it may be necessary to perform this repeatedly. In using the curette great care must be taken not to perforate the thin sphenoidal roof on account of its important relations.

The results in sphenoidal sinus operations are very satisfactory and compare very favorably with the best ethmoidal results.

Treatment if the Cavernous Sinus is Wounded.

In a certain proportion of cases the external wall of the sphenoidal sinus will be perforated by the cutting instrument or curette, and a hæmorrhage into the sphenoidal sinus from the cavernous sinus will result. This hæmorrhage is very profuse and must be immediately controlled in the following way: The finger is introduced through the mouth of the patient into the naso-pharynx and the palate is dragged forcibly forward, so as to allow the finger to pass into the posterior nasal choana on the operated side. Shoving the finger forcibly upward and outward, it is possible to fit it into the instrumental opening made in the sphenoidal sinus. The finger is held in this position to control the hæmorrhage until a strip of gauze can be carried on a pair of forceps through the nose and against the tip of the finger which lies against the opening of the sphenoid. At the same instant when the finger is removed from this opening the gauze must be shoved into the opening and enough gauze may be introduced within the sphenoidal sinus to pack the sinus and plug the opening. This will control the hæmorrhage from the cavernous sinus. The gauze should be left in place for three days and then gently withdrawn. Repacking is not necessary if the hæmorrhage does not immediately recur.

PROBING THE ACCESSORY SINUSES.

Investigation of the openings of the accessory sinuses by means of a probe is in our present state of knowledge rather a disappointment. The locations of the openings of these various sinuses have been described in the chapter dealing with the topography and anatomy of the frontal sinus, ethmoid cell, and sphenoid, to which the reader is referred for detailed information. I wish here to append some measurements which may occasionally be of use to the examiner in ascertaining whether he has reached the desired opening of the sinus, but I wish also to remark that these measurements represent average measurments made from the examination of various skulls, and that I have found the greatest variation in many of them. As the result of many measurements I have established the following list of distances, taken from the inner and posterior angle of the nasal orifice. These are average distances for a normal adult skull. In reaching these sinus openings, it is very important that the investigator should introduce his probe at the angles mentioned. Unless this is done the measurements will not be accurate.

NASAL MEASUREMENTS.

In frontal sinus disease, if the middle turbinate is pushed to the septum or the anterior end removed and a probe, bent at an angle of 30°, is introduced into the hiatus semilunaris upward, forward, and slightly outward, it will find the opening of the frontal sinus. Passing on in the same direction, it will enter the sinus. It may discover evidence of necrotic bone or abscess or tumor. The most important evidence follows the removal of the probe, when if there is pus in the sinus it will immediately gush out. Sometimes, instead of passing into the sinus the probe enters an anterior ethmoidal cell. There is no way to distinguish

between this condition unless the probe touches the anterior wall of the frontal sinus.

The distance from the posterior and inner angle of the external opening of the nose is of some importance here.

From this point to the hiatus opposite the junction of the middle turbinate with the nasal wall is 3.5 centimeters (1 ½ inches).

From same point to frontal sinus opening at its lower end is 4.2 centimeters (1 ¾ inches).

From the same point to the floor of the frontal sinus measured with curved probe is 5.4 centimeters (2 ⅛ inches); and to the anterior wall of a moderate sized frontal sinus, same probe, 6.3 centimeters (2 $^{1}/_{5}$ inches).

The distance to the posterior wall of the average frontal sinus, with probe bent at 23°, is 5.2 centimeters (2 $^{3}/_{16}$ inches).

PROBING OF THE ETHMOID CELLS.

With a straight probe passed to the eye side of the middle turbinate from the same external point upward at an angle of 20°.

To the hiatus semilunaris opposite the lower and anterior part of the bulla ethmoidalis is 3.8 centimeters (1 ⅝ inches).

From same point on same angle, from the ethmoid cells to the base of the brain at the division between the anterior and posterior ethmoid cells, is 5 centimeters (2 inches).

From the same point upward to the base of the brain at the anterior wall of the anterior ethmoidal cell is the same measurement as to the naso-frontal duct, 4.5 centimeters (1 ¾ inches).

From the same point to the brain level at the posterior and superior angle of the posterior ethmoidal cell, at the same time the anterior sphenoidal wall, passed up and back at angle of 23°, is 5.8 centimeters (2 ¼ inches).

From same point to posterior end of middle turbinate is 5.2 centimeters (2 $^{1}/_{16}$ inches).

SPHENOIDAL SINUS.

From same point up and back at 24° to the sphenoidal opening is 6 centimeters (2 3/8 inches).

From sphenoidal opening directly upward to the sphenoidal roof in the same line, 7 centimeters (2 3/4 inches).

The posterior wall cannot be reached:—

From same point back along inferior turbinate to Eustachian tube, 6.1 centimeters (2 3/8 inches).

From same point to posterior edge of inferior turbinate, 5 centimeters (2 inches).

From same point to antral process of inferior turbinate where the antrum should be punctured, is 3 centimeters (1 1/4 inches).

To opening of lacrymal duct, 2.3 centimeters (1 inch).

When the anterior tip of the middle turbinate is removed the distance to the drainage sulcus of the posterior ethmoidal cell is 4.5 centimeters (1 3/4 inches).

Fig. 57.—1, Vomer. 2, Septal or perpendicular plate of the ethmoid bone. 3, Triangular cartilages of the septum. 4, Sphenoid. 5, Crista galli and cribriform plate of ethmoid bone.

CHAPTER VI.

DEFLECTIONS OF THE NASAL SEPTUM. OPERATIONS FOR NASAL DEFORMITIES. PARAFFIN INJECTIONS.

ANATOMY.

THE nasal septum is the partition between the two nares and should when normal be absolutely perpendicular and have practically parallel surfaces. Any deviation from this rule may be considered an abnormality. Practically, however, we see very few septums with parallel surfaces or with exact perpendicularity, for slight thickenings or deflections may occur without giving rise to nasal symptoms.

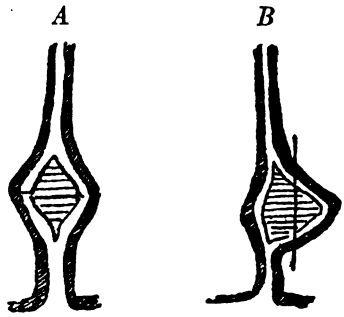
When the septum is considered from the standpoint of the clinician it is the anterior part which interests us, for the posterior bony part is firmly fixed along all of its borders except the posterior, while one-third of the anterior cartilaginous part has no bony attachment.

THE TRIANGULAR CARTILAGE.

The triangular cartilage forms the anterior part of the nasal septum and occupies about a third of its total area. From the edge of the nasal bones it has an unattached surface extending to the tip of the nose, and free under-surface extending from the tip of the nose to the spine of the inter-maxillary bone. The rest of its anterior edge is attached to the under-surface of the nasal bones, while its posterior edge is attached to the septal plate of the ethmoid, and its inferior edge is attached to the vomer and the spine of the intermaxillary bone. (See Fig. 57.)

The free surface of the septal plate of the ethmoid and the upper edge of the vomer are grooved to receive the triangular cartilage, so that throughout the whole of its posterior and

inferior edges the triangular cartilage sets into a V shaped depression on the edge of the bony septum. The triagular cartilage does not end here, but sends a tail-like projection backward to the body of the sphenoid. This cartilaginous projection is surrounded by a bony foramen made up by the union of two half grooves which are formed at the junction of the septal plate of the ethmoid with the vomer. The union of these parts is very weak, and it is along this line of articulation between the



A, Bilateral Thickening or Exostosis of the Septum at the Suture Line. Note the cartilaginous center. *B*, A considerable exostosis and line of saw cut for removal. The saw cutting from below will first cut mucous membrane, then firm bone shell, then soft cartilage, then bone again, and finally mucous membrane.

vomer and the ethmoid that abnormalities of the septum are apt to occur. Exostoses, echondroses (spurs), as well as deflection of the nasal septum are most likely to occur in front along the lower border of the triangular cartilage and its point of junction with the vomer, and further back along the line of articulation between the vomer and the septal plate of the ethmoid. These bony articulating plates are very thin.

THE SEPTAL PLATE OF THE ETHMOID.

The septal plate of the ethmoid is attached in front to the nasal bone and to the triangular cartilage; below, to the vomer.

Fig. 58.—This specimen shows a straight nasal septum and a markedly deflected septum between the two frontal sinuses. There is no relation between the two septa in any way, so far as position is concerned.

Fig. 59.—Deflection of Nasal Septum to Left. The specimen is viewed from behind. The section was made too far forward to cut the middle turbinals, but the anterior tips of the inferior turbinals have been included.

Along the attached edges it is grooved in front for the reception of the triangular cartilage, and behind it articulates with two similar grooves on the vomer, thus making a canal which contains the cartilaginous process from the triangular cartilage.

THE VOMER.

The vomer is attached to the body of the sphenoid and the septal plate of the ethmoid above; while anteriorly it is grooved for the reception of the triangular cartilage, behind, it is unattached and forms the inner wall of the posterior choanæ; below, it is attached to the palatal process of the superior maxillary bone behind, while in front it articulates with the spine of the intermaxillary bone.

THE MAXILLARY SPINE.

The spine of the intermaxillary bone is a prominent thick bony spine about ¾ inch long and ⅛ inch high, which develops from the upper surface of the intermaxillary bone. It is rough, very bony, irregular, and presents a sharp edge in front; while above it is grooved for the reception of the triangular cartilage and behind it articulates with the vomer.

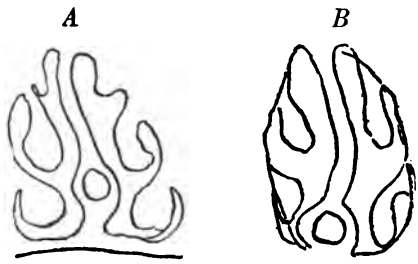
MUCOUS MEMBRANE.

The entire nasal septum is covered with mucous membrane in which numerous blood-vessels ramify. The arterial supply is very abundant and one need never apprehend sloughing of the nasal septum from lack of blood. The nasal branch of the ophthalmic artery supplies the upper part of the septum; the septal branch of the labial supplies the lower and anterior part, a small artery from the facial perforates the nasal bone and further supplies the anterior part of the septum. The main arterial blood supply arises from the septal branch of the spheno-palatine.

This vessel runs from the sphenoid forward and downward along the vomer to the anterior dental foramen, and in its course gives off numerous branches which supply most of the surface of the nasal septum.

Exostoses.

Exostoses (or spurs) ordinarily occur along the line of junction between the triangular cartilage and the vomer, in which case they may be either cartilaginous or bony. If they occur posteriorly they develop between the line of junction of the



A, Diagram Showing a Cross-section of the Nose, with Deflected Septum and Thickening Over the Cartilage Which Fills in the Gap Left in the Sutures Where the Parts of the Septum are Joined. The cartilage is pictured in the center. *B*, Shows a section of such a septum farther forward. The deflection is to the left. The thickening is low down.

septal plate of the ethmoid and the vomer. Ordinarily they are composed partly of cartilage and partly of bone. As these exostoses ordinarily form along the line of junction of the septal plate of the ethmoid and the vomer, and at the exact point where the edges of these bones are grooved to form a foramen which holds the projection of the triangular cartilage, it follows that in removing a bony exostosis one sometimes cuts through the mucous membrane, then through a thin layer of bone, then into cartilage, and again into another thin layer of bone and mucous membrane. (See page 176.) In removing exostoses, they should

Fig. 60.—1, Deflected septum (ridged). 2, Inferior turbinal bodies; the one on the right side considerably hypertrophied. 4, Thicker upper part of nasal septum. Above this are the two sphenoid sinuses; the left side is the larger. This section is viewed from the naso-pharynx.

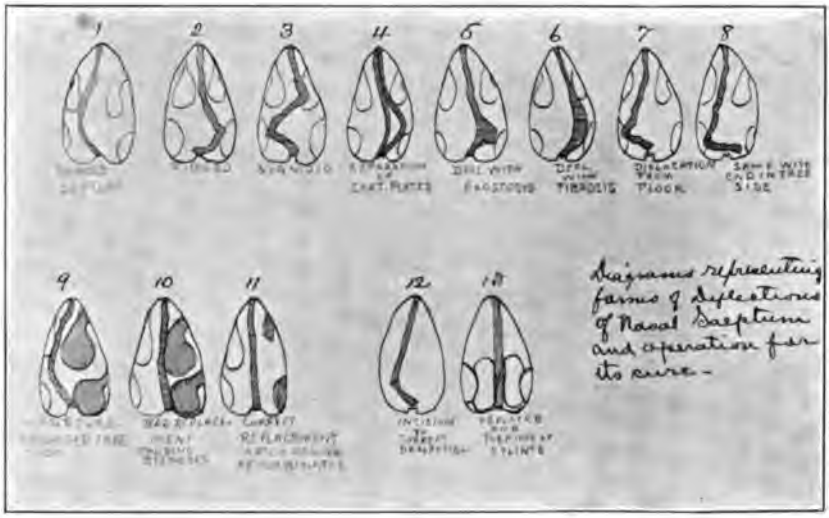


Fig. 61.—1, Bowed form of septum. 2, Ridged form (note the sharper angle of deflection). 3, Sigmoid or double, or Z curved form. 4, Deflected and thickened. Such thickening usually occurs on the narrow or convex side. The thickening may be bony, as in 5, Exostosis, or fibrous, as in 6. 7, Dislocated and bent form. 8, Extreme type of 7. 9, Deflected septum, with turbinal bodies hypertrophied to fill up concavity. These overgrown turbinals must be reduced before the septum is replaced in the center of the nose.

always be sawed from below upward, and care should be taken to remove them as far back as they extend. The operator must remember that the line of articulation between the vomer and the septal plate of the ethmoid is higher from the floor of the nose behind than in front. Occasionally another form of exostosis is found within the nose, consisting of a hyperplastic bony mass throughout on the surface of the vomer. In such cases the thickening contains no cartilage.

Deflections of the Nasal Septum: Forms of Deflection.

If the nasal septum deviates from the middle line it follows one of two simple forms of deflection: that is, it may be either bowed—in which case the septum bends gradually into the obstructed nostril in such a way that the line of the septum is concave in one nostril, convex in the other; or it may be angular, in which case the line of deflection is more acute and generally forms a ridge in the obstructed side, while in the opposite side a distinct depression is seen. If the traumatism which produces the deflection is enough to fracture the septum, then the deformity is generally angular. If the traumatism does not act so powerfully, then the septum is partially fractured—green stick fracture, for instance—and is bowed.

All septal deflections may be classified under one of these two heads. There are, however, certain sub-varieties of these two great classes of deflection:—

1. The bowed septa, besides being deflected, may be thickened. This variety is called *bowed septa with thickening*. The thickening generally occurs upon the convex side and is the result of osseous or fibrous tissue thrown out in the process of healing.

2. The bowed septa may be deflected on two lines—the

lower deflection into the inferior meatus and the upper deflection into the middle meatus. This form of septa is called *sigmoid.*

3. The angular deflections of the nasal septum may also be accompanied by thickening on the deflected side, which gives rise to a form of deflection known as *angular deflection with thickening.*

4. An angular deflection may also be doubled—presenting one deflection into the inferior meatus, and another deflection into the middle meatus. This form is known as *angular sigmoid deflection.*

5. There is still another form of deflection, which is often mistaken for an exostosis. It belongs to the type of angular deflections with thickening, but the thickening occurs on the *concave side* in the region of the deflection. The deposits of fibrous tissue produce a thickening around the concavity which obliterates the evidence of deflection and makes the nostril appear as if it were the seat of an exostosis. In such a case one nostril will be obstructed by the apparent exostosis, and the opposite wall of the septum will be fairly perpendicular. It is only with a probe that the difference can be discovered. This instrument will discover on the concave side, a slight fold or pit in the mucous membrane extending along the line of deflection. Unless the probe is used in the examination this form may be overlooked and the septum operated on for exostosis. The result would be the perforation of the nasal septum.

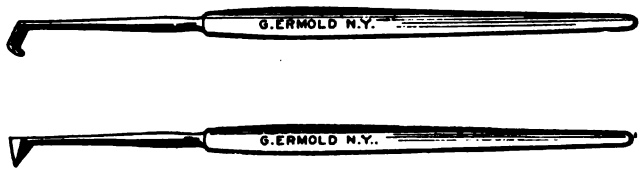
PRINCIPLES OF OPERATION.

The first attempt of the surgeon in all cases of septal deflection should be to reduce the complicated forms of deflection to either a simple bowed deflection or a simple angular deflection. This may be done by the knife or saw in removing all the thickenings which occur. A well-greased finger introduced

Fig. 62.—The Nasal Septum, showing perforation with the spear knife to make a small hole through which a bistoury is used for further incision (see Fig. 75).

in the unobstructed side will give one a better idea of the thickenings of the nasal septum than any other method of examination. After these have been discovered, they may be removed with the saw or knife, and the work of correcting the deflection will be very much simplified. *In many cases if the thickenings are carefully removed it will not be necessary to do an operation for the deflection.* This very important point cannot be too strongly emphasized.

The illustrations above show how the more complicated forms of septal deflection may be reduced to the simpler forms of bowed or angular deflections by the removal of thickenings. (Fig. 61.)



Author's Septum Knives.

When the saw or the knife has been used to reduce the thickenings, all the forms of septal deflection will fall under one of four classes: either they will be (1) simple bowed, (2) sigmoid bowed, (3) simple angular, or (4) sigmoid angular. If at this stage obstruction occurs it is necessary to proceed further with the deflected septum operation, the second principle of which is to cut through the nasal septum along the lines of its deflection—either at the point of greatest curvature if the septum is bowed, or along the line of greatest angle, if the form of deflection is angular.

Incisions.

The second principle in septal work is then to cut the ridges or lines of deflection in whichever direction they may extend.

The object of these incisions through the cartilaginous parts of of the septum is to lessen the resiliency of the septum, to make a slight overlap possible, and to sever bands of fibrous adhesions which form in the perichondrium and serve to hold the septum in its displaced position.

After the operator has removed the thickenings of the nasal septum, he will then have one of four forms:—

1. Either the septum will be a single bowed septum having a convexity in one nostril and a concavity in the other;

2. Or it will have two bowed deflections (sigmoid septum) in which one deflection will be above the other and the septum will be curved into one nostril and then into the other so as to have the form of the letter **S**;

3. Or the deflections will be angular when they may be considered a simple angular deflection, or a double angular deflection.

In the case of bowed septa, the incision is made over the situation of greatest curvature; or, if there are two bows, two incisions are made—one over each curvature.

In angular septa the incision is made through the line or ridge of deflection; and if it is a double angular deflection two incisions are made—one over each ridge of deflection.

The incision is commenced by making a buttonhole through the nasal septum with the point of a sharp knife. This buttonhole should be about half an inch long and should extend through the thickness of the septum. A spear-pointed knife is a convenient form with which to make this incision.

Into the buttonhole made through the septum, at the point of deflection, a curved and blunt-pointed bistoury should be introduced, and the incision should be carried forward along the angle of deflection to the epithelium of the nose. The knife is now turned backward and the incision continued along the line of deflection as far back as the soft cartilaginous tissue extends —that is, to the edge of the bony septum. If a second incision

Fig. 63.—The Nasal Septum Seen from the Left Side. The knife is making the incision necessary to the straightening operation. The incisions follow the angle of deflection as far as the deflection extends and in the direction taken by the deflection. The frontal sinus, ethmoid cells, and sphenoid are also seen in this section.

is necessary on account of the presence of other lines of deflection, then this is made in the same way following this other line of deflection. Each deflection should be cut as far backward and as far forward as it extends.

At this stage of the operation the septum will show one or two cuts through its entire thickness, each cut severing a line of deflection and extending from the most forward to the most posterior part of the deflection. In most cases the deflections run antero-posteriorly, but in a few instances the deflection is vertical. In such cases the deflection is always located well forward.

The rule for vertical deflections is the same as for other deflected septa—that is, the deflection must be cut along the line of deflection as far as it extends, so that in such a case the incision will be vertical instead of horizontal or oblique. No danger need be apprehended from sloughing of the nasal septum as the result of lack of blood-supply. The incisions therefore may be made freely. Indeed sloughing and perforation is more often produced by neglect to approximate the uncut edges than by lack of blood supply.

Use of Forceps.—The third principle of septal operation is the freeing of the triangular cartilage from its points of attachment. Septal forceps are used for this purpose. To break the triangular cartilage from the spine of the intermaxillary bone and from the upper edge of the vomer, the forceps are introduced within the nostril—one blade in each naris—and are crowded down to the floor of the nose. The septum is then firmly grasped with the forceps and moved first to the right and then to the left a sufficient number of times to satisfy the operator that the triangular cartilage is freed from its attachment to the floor of the nose.

The forceps are now removed and reintroduced. This time they should lie parallel with the nasal bones. When they are in this position and are rocked and rolled as above described, they

tear the triangular cartilage from its attachment to the septal plate of the ethmoid. Care must be taken in fracturing the triangular cartilage from its attachment not to drive the edge of the forceps too far into the opposite nostril, else the triangular cartilage will be torn too far away, the soft tissue will be lacerated, and a perforation will result.

When the triangular cartilage has been thoroughly broken from its bony attachments, the anterior part of the septum is freely movable into either nostril. With the little finger placed into the side which was obstructed, the cut and fractured triangular cartilage is pushed into the opposite side a little past the median line. In doing this a very slight overlap frequently takes place along the edges of the incision, especially if the incision through the cartilage is slightly bias. If the septum does not yield readily to the pressure of the finger and accept the new position in which it is placed, the bands of adhesion or its points of attachment have not been properly freed and the forceps should be used again. The attachment of the triangular cartilage to the spine of the intermaxillary bone will be found to be the point most resistant to correction. It is often necessary to sever this spine with a chisel and mallet in such a way as to leave the upper part of the spine attached to the triangular cartilage. This allows the anterior part of the septum to be shoved freely from one nostril into the other. After the septum has been pushed to the median line it should be examined by sight to determine if it is thoroughly perpendicular.

It should be held in place while it is healing by means of nasal splints. The best form of nasal splint is compressed cotton in the form of Simpson's nasal tampons. If it is desired to use hard rubber or metal splints, McKernon's are preferable to the Asche or Meyer.

AFTER-TREATMENT. — The splints which are introduced within the nose to hold the septum in place should be sufficiently wide to produce a slight over-correction, so that the septum

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Fig. 64.—Forceps for Septum Operation in the *First Position*. It grasps the septum parallel to the floor.

will be displaced slightly into the opposite nostril. Sometimes two splints are used—a larger one in the formerly obstructed side, and a smaller one in the other. The best support is given to the nasal septum by means of long narrow pieces of Simpson's nasal tampons, packed along the side of the mucous membrane of the septum. Enough thicknesses of this form of compressed cotton should be placed in the formerly obstructed side to make firm pressure against the septum when the cotton is swollen, and in the opposite nostril a single thickness of sponge only is necessary. The objection to the Simpson sponge is that it is not perforated and does not allow nasal breathing, but this is a very slight objection when compared with the gentle, constant, and regular pressure which it makes against the cut surface. It holds the septum in place better than any other splint of which I know. The quantity of pressure may be regulated with the nicest gradations. With the hard splints no such constant or gradual pressure is possible.

For the first twenty-four hours after a septum operation the patient should be inactive, and perhaps kept in bed. Temperature and general constitutional disturbances should be combated by treatment if they are present. Hæmorrhage is rare after septal operations, for the splints act as effective plugs to prevent bleeding. Therefore, if there is no temperature and if the amount of pressure made by the splints is satisfactory, there is no reason for removing these splints for the first twenty-four hours. At the first dressing the splints are removed by very gentle traction, care being taken not to tear away any tissue. After the splints are removed, the mucous membrane of the septum and the adjacent parts will be found considerably swollen, and should be contracted with a 2 per cent. solution of cocain and a 1 to 10,000 solution of adrenalin chlorid. This prevents bleeding and allows painless treatment. The nostrils should then be irrigated or sprayed with sterile normal salt solution. When thoroughly cleaned the membrane should be treated with a protective and antiseptic powder.

The splints should now be reintroduced if they are of the hard variety, or if Simpson sponges are used, new strips of this cotton should be placed alongside the septum for its support. Generally after the first forty-eight hours it is possible to dispense with the use of splints on one side, leaving the support only on the side which was formerly obstructed. If the septum has not remained in the median line, it may be replaced by gently pressing to one side or the other with a periosteal elevator or with the blunt handle of a scalpel.

The next dressing, unless there is a considerable discharge, should be done after another forty-eight hours. At the second dressing, if granulation tissue has sprung up, it should be burned with nitrate of silver fused on the end of a probe, or with a small quantity of chromic acid. After the septum has been again cleansed and powdered, the supports are reintroduced. Great care must be exercised that the septum occupy a position in the median line, for after this dressing the wounded septum is apt to be united enough to prevent easy replacement in subsequent dressings.

Subsequent treatment is carried out along the same line. The supports to the septum should be worn for two weeks. Sometimes a month or so after the operation a thickening will form along the edges of the cuts which it may be necessary to remove with a fine saw or a sharp knife. These complications are fortunately rare. Perforations are also rare. Should perforation occur, no great harm follows except a few disagreeable symptoms resulting from scab formations along the edges of the perforation, and occasionally hæmorrhage from its exposed surface.

THE ASCH OPERATION.

The Asch operation consists of three steps:—

1. A crucial incision over the deflection.
2. Fracture of the septum.
3. Replacement and support.

Fig. 65.—The Septum Forceps Applied in the *Second Position*—Parallel with the Nasal Floor and Grasping the Lower Part of the Triangular Cartilage, and the Anterior Part of the Vomer. In the *second* position the forceps grasp the upper part of the triangular cartilage, and also a part of the septal plate of the ethmoid bone. Incidentally, note here the frontal sinus, the ethmoid cells, and the sphenoid; also, the naso pharynx. All well shown.

The crucial incision is made by means of specially devised instruments known as the Asch cutting forceps. One instrument makes a horizontal incision and the other a vertical one. The instrument cutting horizontally is introduced, one blade in each naris, and the horizontal incision is made over the point of greatest deflection. The instrument is then withdrawn, and the instrument making the vertical incision is adjusted within the nostril over the middle of the horizontal incision. In this way a vertical incision is made. These two form what is called a crucial incision.

In the second step, the septum forceps are introduced within the nostril near the floor of the nose and the septum is freed from its attachment to the floor by a rocking or rolling motion. The forceps are then inserted over the incision and rocked from side to side. It is claimed by the advocates of this operation that the forceps break the fibro-cartilage into several pieces, but this statement is absurd and the breakage is impossible. As a matter of fact, the cartilage cannot be broken by the Asch forcep, but it is freed from its attachment to the bony septum.

In the third step of the operation the septum is replaced in the median line, and a septum tube is used as a nasal splint. The after-treatment of these cases is the same as has been described on page 195.

THE GLEASON OPERATION.

The Gleason operation consists of making a tongue or flap of the cartilaginous septum in the region of the deflection. This tongue or flap is then shoved through to the opposite side where it projects within the formerly free nostril and adhesions form. The operation is performed with a saw. A long, fine-bladed, cross-cutting saw is introduced within the nostril on the obstructed side below the point of deflection, and the septum is sawed through its entire thickness, making an intentional perforation. This incision is continued upward for about 1 ¼ inches.

If the saw is introduced below the deflection, as it proceeds upward it makes a cut in front and behind the deflection so as to leave the deflection in a tongue or flap of septal tissue. If the cut is carried upward at a very slight angle through the septum, it will leave the incision with oblique edges. The tongue-shaped flap may then be pushed through to the other side, when its resiliency will tend to make it return, but it will be caught and held against the edge of the lower and uncut part of the nasal septum.

These two edges should then reunite. As the result of this operation the deflection is transferred from one side to the other and is not corrected, but there is more space for respiration in the formerly obstructed side, and less space in the formerly free side. After the septum is healed, it is often necessary to remove by means of a saw the new callus which will form on the side to which the septum has been shoved.

SUBMUCOUS RESECTION OF THE SEPTUM.

The nose is made ischemic and anæsthetic by the use of suprarenal and cocain solutions, as before described. The operator then introduces a speculum into the convex side and with a sharp-pointed scalpel or bistoury makes an incision through the mucous membrane from behind forward and just below the greatest angle of deflection. When the incision has reached a point forward, which is in front of the deflection, it is continued upward as a curved incision to a point above and in front of the deflection. A small periosteotome is now used to separate the mucous membrane and the perichondrium from the triangular cartilage. The periosteotome is first used to make a superior flap, which when freed is turned upward against the nasal septum and held in place with a plug of cotton placed between it and the middle turbinate body. This holds the superior flap entirely out of the way. The periosteotome is then used to separate the mucous membrane from the septum—beginning below

Fig. 66.—Large Hole in Nasal Septum. Most of the cartilage and some of the bony septum is gone. It is the result of a tertiary syphilitic ulceration.

the incision and extending a sufficient distance downward toward the floor of the nose to uncover the area below the deflection. The triangular cartilage is then incised backward, care being taken not to perforate the mucous membrane of the opposite side. As soon as it is incised, the edges of the incision are pulled apart and the periosteotome is used through the incision in the triangular cartilage to separate the cartilage from the mucous membrane and the periosteum of the opposite or concave side. It requires careful work to avoid perforating the mucosa of this side, for the point of deepest indentation of the perichondrium is often firmly adherent to the cartilage.

When a sufficient quantity of cartilage has been freed from the mucosa of both sides, it may be removed with a punch or other suitable cutting instrument, and if enough of the cartilage has not been removed more of the mucous membrane on each side of the septum may be separated by the same method, and the cartilaginous or bony septum removed as it is exposed.

In this way most of the cartilage and a part of the bony septum may be removed. After the operation any particles of cartilaginous or osseous *débris* are carefully removed, the periosteal surfaces and the septal mucosa cleansed, and the two surfaces are allowed to come in apposition. For the first forty-eight hours they may be held in place by a plug of cotton or gauze, after which all plugs may be removed. Some operators stitch the edges of the flap together, but this is not necessary. Apposition by means of pressure is sufficient, and allows better drainage if drainage is required.

RESULTS.—It is claimed for this method that after the removal of the cartilaginous and bony septum that thick bands of fibrous tissue form on each side of the perichondrium and make a new septum.

The objections to the operation are the length of time required to accomplish it, and the fact that perforations often result from sloughing or from instrumentation.

DEFLECTIONS OF THE BONY SEPTUM.

There is no cutting operation to be performed for deflections of the bony septum. In fact, the bony septum is so well supported by the cranial bones that it is protected from traumatism. If a deflection of the bony septum occurs it is generally in connection with the triangular cartilage, and is usually restricted to the anterior edge of the ethmoid septal plate, or the upper edge of the vomer. It is very rare to find a deflection of the bony septum without a deflection of the triangular cartilage.

If the bony septum is deflected, the best we can do with it up to the present time is to attempt to fracture and replace the deflected bony surface with the same forceps which are used for correction of the deflection of the triangular cartilage. There is, however, danger of exciting a pachymeningitis, and some danger of fracture of the base of the skull in the anterior fossa. When the bony septum is deflected the submucous resection of the septum, as above described, should be performed.

EXTERNAL NASAL OPERATIONS FOR THE RELIEF OF DEFORMITY.

The Saddle Nose Deformity.

This deformity is produced by the absence of the triangular cartilage and a subsequent sinking in of the nostril between the tip and the end of the nasal bones. The name describes the appearance of the deformity.

Until treatment by paraffin was introduced for the relief of this deformity, results were more or less unsatisfactory and doubtful, and it is unnecessary here to discuss procedures in which artificial bridges or supports are used to relieve this form of deformity.

Ordinarily paraffin injections, if carefully performed, pro-

duce improvement in the appearance of the patient, although sometimes the results from paraffin leave much to be desired.

The paraffin is injected by means of a hypodermic syringe, and may be used in either a liquid or a semi-solid state. If used in a liquid state, diffusion of the paraffin to the surrounding tissues and embolus are more apt to occur. If the paraffin is used semi-solid, it is less apt to produce undesirable complications.

PREPARATION OF THE PARAFFIN.—Commercial paraffin melts at too high a degree of heat for use in the syringe, and its melting point must be lowered by the addition of oil of paraffin (liquid paraffin). The following table will be found useful to produce paraffin at any desirable melting point:—

Parts of Paraffin.	Parts of Liquid Paraffin.	Melting Point.
1	4	38°-40° C.
2	5	42° C.
4	6	44° C.
5	5	48° C.
6	4	50° C.
8	2	56° C.

The commercial paraffin should be thoroughly cleansed by putting it in a vessel of boiling water and boiled for one hour with occasional stirring. The melted paraffin will remain upon the surface, and when the water is cool will form a cake. After cooking the paraffin for one hour it should be cooled and removed, placed in fresh boiling water, and boiled for another hour. This will dissolve out the soluble chlorids and sulphates which are found in commercial paraffin. The purified paraffin should be wrapped in sterile towels and used as needed, to prepare the mixture for injection.

When desired for injection, it should be mixed with the proper proportion—by weight—of liquid paraffin (oil of hydrocarbon), as per the above table, and these two should be placed

in a sterile cup, melted together, and mixed. This product may now be sterilized in a closed bottle for an hour and is then ready for injection.

To obtain a semi-fluid paraffin for injection, it should have a melting point of about 101° F. (38.5° C.). When this product is injected by means of a hypodermic syringe, it will ooze from the point of the needle like vermicelli, and the injection may be performed evenly and regularly. If it is desired to use melted paraffin, a mixture having a melting point of 104° F. (40° C.) should be used.

When semi-solid paraffin is used the injection syringe may be sterilized and filled with the sterile paraffin and reserved for use at any time. The product will remain sterile within the syringe. If the liquid paraffin is used, it is necessary before the operation to melt the paraffin and fill the syringe while both are hot. The syringe is warmed by immersing it in boiling water, and it will remain hot long enough to prevent the paraffin from solidifying while it is being drawn into the syringe. The filled syringe is then kept under hot water (130° F.) until the patient is ready for its use.

The nose upon which the operation is to be performed is cleansed with green soap and hot water one hour previous to the operation. This will allow time for the hyperæmia resulting from the rubbing to subside. After cleansing the nose, it should be covered with sterile gauze, and just before the introduction of the needle the skin of the nose should be washed with ether. Under sterile conditions, the operator should pinch up the skin of the nose over the deformity between the finger and thumb of the left hand. He should then introduce the needle beneath the skin at the lower point of the deformity until the needle is within the fascia. The needle should then be moved sideways so as to tear a small cavity in the fascia in the region of the deformity for the reception of the main mass of paraffin. The paraffin should now be slowly injected while an assistant makes pressure

over the sides and bridge of the nose, to prevent the paraffin from running along the fascia to the eyebrow or lid, or forehead. This danger is practically obviated by using semi-solid paraffin, but is imminent if liquid paraffin is injected.

The needle for the hypodermic syringe should be short and of rather large caliber. A liquid paraffin solidifies within a small needle, and further injection is often prevented.

As soon as the paraffin is injected, it spreads out as a little lake or puddle and soon solidifies. Before it is solidified it may be moulded by means of the fingers. The moulding may be further aided by very hot compresses placed over the nose.

THE DANGERS OF THE PARAFFIN INJECTION are:—

1. Blocking up of the nostril. This results when the paraffin is injected into such a part of the nose that it does not receive a firm base of support. This complication is very apt to occur if the ala of the nose is injected. In this case the paraffin will form as much of a swelling within the nose as it does externally and often results in the blocking up of the vestibule.

2. The second danger is that of embolus. If the needle perforates a vein, the liquid paraffin is injected into the venous system and forms a paraffin embolus. In one case, at least, this has produced serious results.

3. The third danger is the displacement of the paraffin. If the paraffin is injected liquid, it will often dissect the fascia and appear at places where it is undesirable that it should remain. It is apt to make its appearance on the forehead over the median line, over the eyebrows, and sometimes in the under eyelid. At each of these points, if it infiltrates, it produces a tumefaction and more or less deformity.

4. The fourth danger is that of hyperæmia. In some cases if the paraffin is injected within the skin, instead of into the fascia beneath the skin, it will produce a chronic hyperæmia of

the skin, with discoloration of the surface. This will remain for months before it disappears, but will eventually correct itself.

5. Obstruction of the lymphatics. The danger of obstruction of the lymphatics is one of the most disagreeable features associated with the injection of paraffin. It is a complication which is apt to occur a considerable time after the injection, and manifests itself by a brawny swelling in the neighborhood of the injection. I have seen it occur from three to five weeks after the paraffin is used. The condition is analogous to the obstruction which occurs in a milk leg, and when present produces a uniform whitish swelling which is apt to destroy the cosmetic effects of the operation. This is especially apt to occur when the injection of paraffin is used for other purposes than for elevating a depression in the nose, and has been oftenest observed in the skin of the neck, in the region of the mammary gland, over the clavicle; and in one case where a finger was injected with a drop of paraffin to relieve a deformity, the finger swelled enormously throughout its whole length and a thickening resulted nearly twice the size of the original finger.

Removal of Paraffin.—When the paraffin has once been injected, its removal is attended with the greatest difficulty. Something may be done to diffuse the paraffin through the tissues if the parts are superheated by means of hot dry air or very hot applications, while at the same time the operator vigorously rubs the parts containing the paraffin. Some of the paraffin may be diffused through the adjoining tissues, provided encapsulation has not occurred. If encapsulation has occurred, the only methods of removing the paraffin are by means of an incision over the injection reaching to the paraffin, and a careful curettage with a sharp spoon. If an abscess forms and a discharging sinus results from the injection, the paraffin may be removed with a sharp curette through the sinus opening. Repeated scrapings are necessary to remove the entire paraffin, and this had better be performed at intervals of four or five days.

Electrolysis as a methid of melting the paraffin, which has subsequently to be squeezed out through a small incision, has been tried by various surgeons, but without success.

The Relief of the Roman Nose Deformity.

In the Roman nose deformity the median ridge of the nose is usually prominent, either from an anatomical deformity of the nasal bones or as a marked over-development in the upper and anterior angle of the triangular cartilage, which forms a beak-like prominence. This is to be relieved by an incision in the median line over the point of deformity, extending to the periosteum or perichondrium. The incision should be as small as possible—only large enough to admit the instruments which are to remove the beak-like angle. The lower edge of the nasal bones are removed with a sharp chisel, care being taken to reduce the nasal deformity a little at a time, and in successive layers. As soon as the triangular cartilage is exposed it may be cut down with a sharp knife. In this way the beak-like deformity is cut away, and when the proper cosmetic effect has been produced the operator sutures the skin incision with a very fine needle and thread. Sometimes plaster is used to bring the edges together, instead of a suture. The after-treatment is carried out on ordinary surgical lines.

Relief of the "Crooked Nose" Deformity.

In this deformity sometimes the whole of the nose, and sometimes only the tip, is deviated from the median line to one side or the other. This is generally the result of congenital conditions, in which one side of the nose is developed more rapidly than the other, or of a traumatism which will produce a similar displacement. When the deformity is confined to the tip of the nose, it is always associated with some deflection of the nasal

septum, together with the spine of the intermaxillary bone. It is frequently an accompaniment of a high-arch palate; in other cases, the deformity will involve the entire length of the nose, beginning at the base of the nasal bones where they are attached to the frontal, and extending to the tip of the nose. In this class of cases the entire nose is deflected, the deformity gradually increasing from the base of the nasal bones to the tip of the nose. In almost every instance this form of deflection is also accompanied by a septal deflection which must be corrected before the cosmetic operation.

When the tip of the nose alone is displaced, it may be improved by correcting the displacement of the intermaxillary spine and the triangular cartilage. If care is taken at the time of the septal operation to break the spine of the intermaxillary bone as described on page 192, it will be possible to shove the tip of the nose into the median line and to retain it there with ordinary nasal splints, such as are used in septal deflection, until it is united in its normal position.

In those cases where the displacement begins at the base of the nasal bones, it is necessary to adopt a different technique to correct the deformity. An incision a quarter of an inch long, extending to the periosteum should be made over the base of each nasal bone. A chisel is then introduced through the cut to the base of the nasal bones, which are chiseled free from their attachment to the frontal. Through the same incision the chisel is forced sideways and downward through the suture between the nasal bone and the nasal process of the superior maxillary bone. This suture is likewise chiseled. When this has been done on each side, the nasal bones are quite free from any bony attachment, and may be moulded into the median line by means of nasal forceps—one blade of which is introduced within the nostril, grasping the inner surface of the nasal bones, while the other blade closes down upon the facial surface. By gentle twisting, rocking, and rolling motions applied to each of the

nasal bones in turn, they may be completely loosened so that they may be replaced in any desired position—the nose may be narrowed, or the bridge raised, according to the design of the operator.

If a septal operation is necessary, it should be performed before the operation for the relief of the external deformity. After the nose is replaced in the desired position, it should be held in position by strips of gauze packed within the nostril, and by the application of a properly moulded splint to the outside. This splint should be worn for a week or ten days.

CORRECTION OF VARIOUS DEFORMITIES ARISING FROM ABSENCE OF ANATOMICAL STRUCTURE.

Repair of the Columna and Septum.

If the loss of tissue is limited to the columna nasi and adjacent part of the septum a new columna may be formed from the upper lip. An incision should be made on each side of the median line on the lip throughout its whole thickness, one-third the width of the lip and in length equal to its depth. The flap is turned up and adapted to the freshened edges of the nose, and sutured. The epithelium of the lip is gradually transformed to squamous epithelium. The incision from which the flap is taken should be sutured as for harelip. It is well to use a silver tube to keep the nares patent.

Deficient alæ may be repaired, if the loss is not too extensive, by a flap from the upper part of the nose. If the deficiency is extensive, a flap from the cheek will be required. In most cases cheek flaps should be made along the naso-labial furrow. Sometimes part of the nose have been constructed from tissues from different parts of the body, fingers, or the arm. If the finger is used, the nail and bone must be removed, the finger split longitudinally to make a flap, this secured to the freshly made new edges of the deformity, and the entire hand held in position

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by a plaster bandage. After the finger has adhered it may be cut from the hand, the edges freshened, and secured to the raw edges of the nasal deformity with interrupted sutures. In all cases the flap must be one-third to one-half larger than the defect to be covered, in order to allow for shrinkage.

Undue shortness is repaired as sunken nose, and is later described. Undue length of the nose is repaired by taking a wedge-shaped piece, or two pieces at right angles to each other, from the thickened tip and closing the wound by sutures.

Operation for Depressed or Sunken Nose.

The first form is where the cartilaginous part is destroyed.

In this case a satisfactory operation may be performed by making an incision on one side of the median line of the nose, parallel to and as long as the deformity, into the fascia. With a tenotome the skin is separated from the underlying structures on both sides from the tip of the nose to the nasal bones. An artificial support is then introduced subcutaneously. I have found celluloid or dental moulding the best material. The support having been properly shaped, it is shoved beneath the upturned skin and the incision is closed by buried suture. Great care must be taken as to asepsis, for on the least appearance of pus the support must be removed, the wound cleansed, and the support reintroduced.

Deformed Nose When Bony Structure is Involved.

In sunken noses in which the bone is involved it is necessary to raise the bridge, which may be done by two methods. When the nasal bones are widened and separated, it is sufficient to grasp each nasal bone with the blade of a septum forceps—one blade inside, the other outside—the latter being protected by a bit of gauze from wounding the skin; then bend each nasal bone

inward and forward till it is broken from its attachment to the superior maxillary bone, when it can be raised at will. Both bones may now be lifted. In a few cases where the forceps do not suffice, the mallet must be used. It is also possible at this stage to make the nasal bones assume any desired angle with the frontal bone, as well as to raise them for cosmetic purposes. No support other than an ordinary spectacle clip is required to hold the bones in position.

Thickening of Nasal Bones.

Where the nasal bones are thickened as well as sunken, a different treatment is required. A small incision should be made over the widest and thickest part of the nasal bone, the periosteum separated, and the bone thinned with chisel and mallet. This is done on each side. The bones are then split in the median line with a chisel and mallet, which will result in giving complete mobility of both nasal bones. They may now be raised and adjusted at any desired angle with the frontal bone. After two weeks the case is considered well, and the cartilaginous portion, if sunken, is then operated upon.

Cases Where Nasal Bones Have Been Absorbed or Septum is Absent from Necrosis.

In cases where the nasal bones have been absorbed or the septum is absent from necrosis these methods do not apply. In these instances the soft parts must be supported on a bony base as well as raised. The nasal process of the maxillary bone having been divided into an upper and a lower flap, each part is turned forward toward the median line, thus making an artificial bony support. If this method is not available, artificial bridges of silver, platinum, and rubber, may be used sometimes with good results, but these finally act as foreign bodies and slough out. The best operation for this has been described by

Weir and later by Roberts. It consists in making a transverse incision across the most depressed part of the nose, thus opening the nasal chambers and enabling the surgeon to pull down the tip of the nose so that the plane of the nostril is horizontal where it had formerly been almost perpendicular. This leaves a gap to be filled between the root of the nose and the tip. This is done by taking flaps from the cheeks and turning them (one from each cheek) inward, so that the skin surface lies next to the nasal cavity. The tissue of the forehead is then brought down to cover these flaps, making a thick mass of tissue which afterward shrinks enough to give an improved appearance to the shrunken nose. The incision at the forehead is sutured.

Another method is making a **V**-shaped incision between the eyes, the point of the **V** being up, and pulling this down to fill the gap.

Tuberous Noses.

Tuberous nose should be treated by removal of part of the tissue which is hypertrophied. If the skin is involved in the tuberous process, a circular or wedge-shaped piece is taken out until the deformity is corrected, the incision being then closed and sutured.

Angular Noses.

The angular nose is best remedied by making an incision on one side of the nose and separating the skin with retractors, drawing the edges of the wound away from the median line till the deformity is reached. By means of chisel and knife this is thinned down and the redundant soft parts are cut away until the prominent nose is reduced to a thing of beauty. The incision is subsequently sutured.

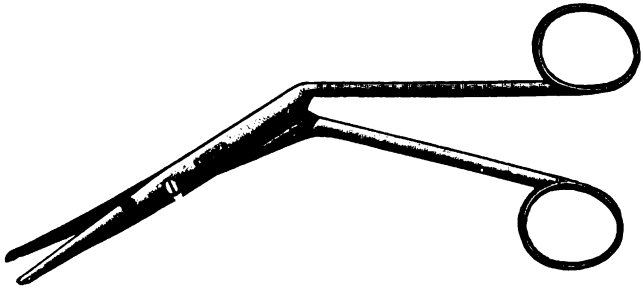
Processes for renewal of the entire nose are described in the Italian, Indian, and Sims's methods, and belong to general surgery—to which text-books the reader is referred.

CHAPTER VII.

TURBINECTOMY.

ANTERIOR TURBINECTOMY OF THE INFERIOR TURBINATE BODY (ANTERIOR INFERIOR TURBINECTOMY.)

THIS operation on the anterior end of the inferior turbinate body is performed for hypertrophy of this end usually in order to restore respiration through the inferior meatus. It is some-



Author's Nasal Scissors.

times performed preliminary to an antrum operation, if the opening is to be made through the antral wall in the inferior meatus.

Method: Pledgets of cotton are packed on all sides of the hypertrophied anterior end. These pledgets are soaked in a 4 per cent. solution of cocain and a 1 to 10,000 solution of adrenalin chlorid. After five minutes the tissue will be anæsthetized. After local cleansing of the part the operator introduces a pair of straight scissors across the anterior end of the inferior turbinate body at the highest point; that is, where it joins the external nasal wall. A horizontal incision is made into the turbinate extending backward about half an inch. The scissors are

then withdrawn and a snare is introduced. The snare wire is placed at the posterior end of the scissor incision, while the tube of the snare is carried over the hypertrophy and shoved posteriorly as far as the snare will go, so as to include the hypertrophied mass within the loop of the snare wire. The snare wire is then slowly tightened and the surrounded end is amputated. The amputated end is removed with a pair of dressing forceps and the stump is treated with an antiseptic powder. A small pledget of cotton may be placed against the amputated end to protect it from infection, and the anterior nares plugged with cotton. Sometimes, if it is impossible to introduce the snare over the hypertrophied mass, the scissors are reintroduced into the incision and the blades turned obliquely downward, and the remainder of the anterior end is completely cut off with the scissors. Generally this removes about a third of the entire mass of the inferior turbinate body. This modification of the snare operation is not to be recommended unless difficulty is met with in introducing the snare over the anterior end.

Inferior Turbinectomy.

When the lower border of the inferior turbinate is hypertrophied it rests against the floor of the nose, making pressure and interfering with drainage and respiration, and sometimes interfering with drainage from the lacrymal duct. When it is desired to remove it, the cocain and suprarenal solution is used as above, and the operation is performed with a pair of straight nasal scissors. This form of scissors is preferable to any of the special forms devised for the removal of the lower border of the inferior turbinate. Care must be taken in this operation not to remove a large part of the inferior turbinate body, for this turbinate is functionally the most important structure within the nose and cannot be removed without danger of destroying some of the nasal functions. Atrophic rhinitis, pharyngitis sicca, and

Fig. 67.—Polypoid Hypertrophy of External Nasal Wall. 1, Polyps. 2, Displaced middle turbinate. 3, Openings of posterior ethmoid cells.

a long list of symptoms from dryness of the respiratory membrane, are apt to result if too much of the inferior turbinate is removed. A good rule is to remove about $^{1}/_{16}$ of an inch of the lower border of the bony part of the turbinate with the attached mucosa. More than this quantity of bone cannot be removed without the destruction of so much mucous membrane as to interfere with the nasal function.

The aim of the operator should be to leave in an adult nose about $^{3}/_{16}$ inch of space between the lower border of the inferior turbinate and the floor of the nose.

After the parts are cocainized as previously described, the scissors are introduced across the inferior turbinate body at such a point upon the body that they will leave $^{3}/_{16}$ inch space between the stump of the hypertrophied turbinate and the floor of the nose. The scissors are then repeatedly carried horizontally backward, snipping the mucous membrane and a fragment of the turbinate bone, and as they reach the posterior third of the turbinate they should be tilted downward. The tendency of the scissors is to work upward on the posterior third and to remove the whole of the posterior end, but this is often undesirable. If the scissors are tilted sharply downward at the posterior third they will cut cleanly through the mucous membrane and the amputated part will fall to the floor of the nose. Oftener, however, the scissors do not completely sever the amputated part from the posterior third, but leave it attached by a shred of mucous membrane, so that when an attempt is made to remove the amputated part from the nose it will be found still attached. It is bad practice to complete the amputation by twisting or tearing away this posterior union. It is much better to reintroduce the scissors and attempt to completely sever the inferior border. In some cases a snare may be slipped over the anterior end of the amputated part and used to sever the posterior attachment.

After the operation the part is powdered with an antiseptic powder, and as there is a special tendency after this operation to

bleed from the venous sinuses it is well to pack gauze or a piece of expanding cotton (Bernay's sponge) against the freshly cut surface.

Amputation of the Anterior End of the Middle Turbinate Body (Anterior Middle Turbinectomy).

To remove the anterior end of the middle turbinate body, the nose is prepared in the usual way with cocain and adrenalin. The field of operation is thus anæsthetized. A pair of nasal scissors are then introduced across the middle turbinate body just at its junction with the external nasal wall. They are shoved backward about quarter of an inch, and closed. In this way an incision is made into the narrowest part of the middle turbinate body just where it joins the external nasal wall. This part might be termed the neck or pedicle of the turbinate. The incision is made horizontally backward and is for the purpose of securely fixing the end of the snare wire. A snare with a wire loop about an inch long is introduced within the nose, and the end of the snare wire is placed into the cut which has just been made. This holds the snare wire from slipping and gives a purchase to the wire, so that the tube of the snare may be passed under the turbinate body, the sides of the snare wire enclosing the anterior end. In this way the entire anterior end, for about a half-inch backward is included within the loop of the snare. The tube of the snare rests posteriorly against the lower border of the middle turbinate body. As the wire is tightened, the tube of the snare fixes itself into the middle turbinate and is held firmly in place while the wire cuts obliquely from above downward. In this way the anterior end of the middle turbinate body is removed for about a half-inch, leaving a stump which presents an obliquely cut surface with an inclination from above downward and from in front backward. If enough of the anterior tip of the middle turbinate is removed it is possible to see

Fig. 68.—Section Showing a Snare Encircling the Hypertrophied Anterior Part of (3) the Middle Turbinal Body. 4, Hypertrophied posterior tip of the inferior turbinal body, partly cut and raised upward. 5, The posterior ethmoid cell region, also called the superior turbinal body. 6, Frontal sinus. The opening of the Eustachian tube is also seen posteriorly to the inferior turbinal.

the region of the hiatus semilunaris, the importance of which has been described on page 10.

In some cases adhesions will have formed between the middle turbinate body and the nasal septum, which will prevent shoving the snare wire over the anterior end. In such cases the adhesions should be broken up. In other cases the middle turbinate will present a hypertrophy which will press so closely against the septum or against the external nasal wall as to prevent the snare wire from passing over the turbinate. In such cases a periosteotome should be used to slightly dislocate the middle turbinate from its position and allow the snare wire to pass over it.

After the amputated piece has been removed with the forceps, the stump should be treated with an antiseptic powder and afterward kept clean for about ten days, when the stump will have healed. Adhesions may form between the stump and the septum unless care is taken to prevent it.

In some cases irregularities of the nasal septum or unusual hardness of the bone of the turbinate will prevent the removal of the anterior tip of the middle turbinate with the snare. In such cases it must be removed piece-meal by means of the cutting nasal forceps. This operation, however, is to be condemned unless repeated attempts to remove the anterior end with the snare have failed. It is to be condemned because it leaves a ragged surface which tends to form adhesions; it is more apt to become septic, and is very apt to open some of the ethmoid cells.

Amputation of the Posterior Ends of the Turbinate Bodies.

The amputation of the posterior ends of the turbinate bodies is generally accomplished with a snare. These posterior ends are sometimes very elusive and are not easily caught within the snare. At such times the operation is a very trying one to the

surgeon. Care should be taken not to contract the posterior ends too much by the use of a very strong solution of cocain, for this increases the difficulty in securing the ends in the snare wire. The snare is generally used through the nose, but occasionally it is necessary to operate through the naso-pharynx. In this case the palate is drawn well forward by means of a palate retractor, and a snare with a tube curved upward is introduced behind the palate into the naso-pharynx and over the growth. In doing this operation it is necessary to use a rhinoscopic mirror to see when the snare wire has surrounded the growth. This is also the method of operation for any growth in the posterior pharynx which is too large to seize and remove through the nose. It is always better to operate under cocain anæsthesia than under general anæsthesia.

In England the operation of removal of the posterior ends of the turbinates is performed by means of a spoke-shave instrument or a sharp ring curette. When this is used it is introduced within the nose over the growth and is then pulled forward with a jerk. This method is to be mentioned only to be condemned.

Treatment After Operations on the Turbinate Bodies.

After the operation has been performed the patient should be required to rest until immediate danger of hæmorrhage is past. It will not then often be necessary to use plugs within the nostril to anticipate post-operative bleeding. No patient should be allowed to leave the office until the surgeon is satisfied that there will be no hæmorrhage. Hæmorrhage is not apt to occur from the middle turbinate body after operation, unless it should be from the posterior end. If it is necessary to plug the nostril an antiseptic powder should be blown over the field of operation, then a properly shaped plug of cotton or of compressed cotton (Bernay's sponge), or a strip of gauze, should be placed against the operated part and left there. The gauze may be packed

Fig. 69.—Hypertrophic (Mulberry) Posterior Tip of Left Inferior Turbinal body. The sphenoidal sinus is seen above and below this the posterior part of the nasal septum.

lightly against the turbinate body, unless the hæmorrhage is active. If after waiting an half hour or an hour the patient's pulse becomes slower and oozing of the blood ceases or is markedly diminished, no danger need be apprehended from hæmorrhage unless the patient makes unwarrantable exertion, uses alcoholic stimulants, or excites the heart with tea or coffee. If no hæmorrhage appears with a half-hour or an hour, the nose may be treated with antiseptic powder after clearing it by lightly blowing. A protective plug of cotton should then be placed within the anterior nares and the patient allowed to go home. There is always an oozing of a blood-stained mucus for the first twenty-eight hours after these operations, but no attention need be paid to this. The wounded surface should not be disturbed for forty-eight hours unless there is evidence of sepsis. This is shown by the patient's "taking cold"—that is, headache, febrile movement, stuffiness of the nose, and general prostration. If these symptoms supervene the nose should be washed by means of the douche, the field of operation carefully cleansed, and the antiseptic powder reapplied. If no symptoms of sepsis are present the first cleansing should take place after forty-eight hours. Any plugs within the nose should be carefully and slowly withdrawn so as not to excite hæmorrhage. A little warm saline solution used within the nose will loosen the plugs from the freshly cut surface and often prevent hæmorrhage. After the plugs have been removed the nose should be douched with a normal salt solution, and when perfectly clean an antiseptic powder should be applied. A bit of cotton placed within the anterior nares completes the dressing. This dressing should be repeated every second day until the wound is healed.

After the first week care must be taken to separate any adhesions which may form. This may be done by a periosteotome or other suitable instrument. If this point is not attended to there is danger of synechiæ forming.

CHAPTER VIII.

TONSILS, ADENOIDS AND UVULA.

TONSILLOTOMY.

THE surgical treatment of the oral tonsil consists of cauterization, amputation, or the removal of its base.

CAUTERIZATION OF THE TONSIL.

Cauterization of a tonsil is performed with the electrocautery, the details of the management of which need not be elaborated here. It is sufficient to say that when the current has heated the platinum point to a white heat and the tonsils have been thoroughly cocainized, the hot point is drawn across the tonsil horizontally from behind forward in such a way as to burn a deep furrow across the middle of the tonsil. Two other furrows are subsequently burned parallel to this, one above and one below. These furrows should be burned deeply to the center of the tonsil. The shrinkage which subsequently takes place will reduce the size of the tonsil sufficiently. It may be necessary in a few cases to repeat the burning process, if the tonsil does not shrink sufficiently from the first cauterization.

AMPUTATION OF THE TONSIL.

Amputation of the tonsil may be performed best by means of the tonsillotome—either the Matthieu or the Mackenzie pattern. Occasionally a pair of ordinary surgical scissors may be used to perform this operation, or the tonsil may be grasped with a pair of long forceps and removed with a knife. It is also possible in some cases to enucleate the entire tonsil, using a pair of blunt scissors.

The operation to be recommended, however, as the most satisfactory and the least dangerous is the use of the tonsillotome to remove the projecting mass of hypertrophied tonsil, followed by the tonsil punch to remove the base of the tonsil. The round blade of the tonsillotome is introduced over the tonsil, an assistant crowds the tonsil into the instrument by pressure under the angle of the jaw, while the operator crowds the instrument as far toward the pharyngeal wall as possible. In this way most of the hypertrophied tonsil is included within the instrument, the knife of which is then drawn through the immovable ring and the tonsil is amputated. Should the base of the tonsil require removal, it may be done by means of the tonsil punch.

THE USE OF THE TONSIL PUNCH.

When the tonsils are hidden behind the anterior pillar, or when it is desirable to remove the base of the tonsil after the main part has been amputated, it is proper to use a tonsil punch. This beak-shaped cutting instrument removes each time a small piece of tonsil tissue, and thus by repeated punching the entire mass of the base of the tonsil may be removed, so as to leave a concave surface between the anterior and the posterior pillars of the fauces. It is a good plan to draw aside the anterior pillar with a sharp hook while using the tonsil punch, for this enables the operator to get a better view of the base of the tonsil.

Tonsillar Hæmorrhage.

Hæmorrhage after tonsil operation is not to be feared, for although it sometimes occurs, it can always be easily controlled by proper measures. Hæmorrhage from the tonsil is either from the arterial supply—in which case the spurting bleeding point may be seen if the tongue is well depressed—or the hæmorrhage is capillary, oozing from the entire cut surface. Capillary hæm-

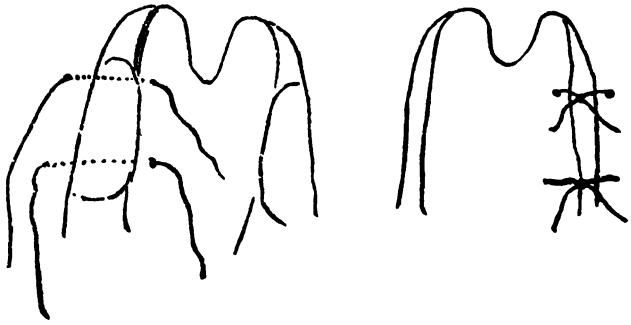
orrhage of the tonsil may be treated with the galvano-cautery or with styptics and with undiluted peroxid of hydrogen, but no cauterizing agent except the galvano-cautery should be used. Therefore strong preparations of iron, chromic acid, or silver are contraindicated. If the hæmorrhage is arterial, any attempt to control it except by pressure will fail. The operator should seize and twist the bleeding vessel. With the mouth well open and the tongue depressed, the bleeding point is easily seen and may be grasped with a pair of long, mouse-tooth forceps. The bite of the forceps should include not only the vessel but a bit of the tonsil tissue as well. The hæmorrhage will cease immediately. The instruments may be left *in situ* for a few minutes

Fig. 70.—Author's Tonsil Needle.

and then slowly twisted until sufficient torsion has been made upon the bleeding vessel to close it completely. The forceps may then be removed and the bleeding point watched. Ordinarily there will be no recurrence.

In a few cases, either of capillary hæmorrhage or of arterial hæmorrhage, these means will fail. It will then be necessary to control the hæmorrhage by suture. A specially devised needle may be used, or in an emergency a Hagedorn needle, firmly fixed in a needle holder, may be employed. The needle, threaded with a heavy silk, should be passed from behind forward through the posterior faucial pillar, then through the upper part of the base of the tonsil, and then through the anterior faucial pillar. This needle will transfix the posterior pillar, body of the tonsil, and the anterior pillar, and should emerge from the anterior pillar a quarter of an inch from its edge. It is then

drawn through, bringing with it the silk, the two ends of which are secured and held by an assistant. Similar sutures are then made in the middle and the lower part of the tonsil, each suture including the posterior and the anterior pillars, and the body of the tonsil. When two or three sutures have thus been introduced they may be tied. In order to do this properly, the fingers are introduced deep within the mouth and the sutures tied firmly so as to fold half of the cut surface of the tonsil upon the other half. This pressure will stop any tonsillar hæmorrhage . (See cuts.)



Figs. 71 and 72.—For Dangerous Tonsillar Hæmorrhage—sutures are passed through the pillars and base of the exsected tonsil, and tied. Two sutures are usually needed.

The sutures should remain undisturbed until they have been loosened by sloughing. They may then be severed and removed. This is generally done on the third day.

Amputation of the Uvula.

The amputation of the uvula should be performed with a pair of straight scissors and a pair of mouse-tooth forceps. The tongue is well depressed and the tip of the uvula is grasped with the mouse-tooth forceps and drawn perpendicularly downward

toward the base of the tongue. This will enable the operator to at once determine the line of demarcation between the hypertrophied tip and the muscular part of the uvula. The scissors are then used to snip the uvula obliquely from in front backward and from below upward, so as to make the scissors cut on the uvula higher behind than in front. When the cicatrix is formed it will contract and lie posterior. After the amputation it is well to cauterize the cut surface with nitrate of silver or touch it with the galvano-cautery to prevent infection, and it is usual to prescribe a warm or cold gargle to prevent reaction. The surface is generally well healed within a week.

Operation for Adenoid Tissue.

The only treatment for adenoids is operative interference. The operator must bear in mind that in an examination the mouth-gag should be introduced before the finger is used to diagnose the condition, otherwise the child may bite the operator. In cases of nervous, frightened children it is better to make the diagnosis by exclusion, without examination, or to make examination under anæsthesia, using nitrous oxid gas.

PREPARATION OF THE PATIENT.

The mouth should be washed with an antiseptic solution, the pharynx irrigated by gargle or douche, and the nose washed out to render the field of operation as clean as possible. This should be done an hour before the operation. A weak solution of hydrogen peroxid, boric acid, or normal salt solution may be used for irrigation. The instruments should be previously sterilized—in other words, the operation should never be undertaken without thorough antiseptic precautions, as cases of sepsis and even tuberculosis and syphilis have been recorded as a consequence of this operation.

Fig. 73.—1, Roof of naso-pharynx, with adenoid growth. 2, Body of the sphenoid bone. 3, Inferior turbinal body. 4, Middle turbinal body. 5 and 6, Superior turbinal tissue, more correctly called "the nasal wall of the posterior ethmoid cells."

THE QUESTION OF AN ANÆSTHETIC.

Undoubtedly all these cases are best operated under anæsthesia, and it may be stated as a rule that no operation for adenoids should be undertaken without general anæsthesia unless there is some direct contraindication to its use. This is not always adhered to in hospital and dispensary practice, but such operations are unscientific. Recurrences are more apt to take place when an anæsthetic is not used. In the choice of anæsthetics we have nitrous oxid, chloroform, and cocain. Nitrous oxid is undoubtedly the most satisfactory, the unconscious period lasting long enough for a quick and skillful operator to do his work. Ether and chloroform can be used by men who do not work so quickly; cocain should never be employed in children, but may be occasionally used with adults who are not nervous and excitable. Just before operation the adenoids should be painted or injected with a 1 to 10,000 solution of adrenalin chlorid in order to lessen the hæmorrhage at operation.

OPERATION.

The patient being anæsthetized and in the sitting or recumbent posture, there is a choice of two methods of operating—forceps or curette, or a combination of both.

Forceps Operation.—The best forceps for this purpose are the Brandagee, and next best the Jurasz. The head may either hang over the edge of the table—claimed by some opertors as preferable—or it may rest on a low pillow. The mouth is opened and an O'Dwyer gag is inserted. If enlarged tonsils are present they should be first removed. The forceps are now introduced through the mouth as far as the posterior pharyngeal wall. Then the finger should draw forward the soft palate, and the blades of the forceps will slip behind the uvula. The forceps should then be pressed upward to the roof of the naso-pharynx.

In this position they should be opened and at the same moment the handle of the instrument should be elevated against the upper teeth. This rotates the blades away from the nasal septum, thus avoiding the danger of catching it. The forceps may now be closed upon the adenoids. A few lateral rotations of the instrument will free the adenoids and bring them away. After most of the growth has been removed by the forceps the curette should be used to complete the operation.

Dangers of the Adenoid Forceps.—In the hands of practiced operators there is no danger from the use of adenoid forceps except that of catching the posterior end of the nasal septum. In the hands of the beginner there are two dangers—that of catching the septum and of tearing away part of the soft palate. In the haste and excitement incident to operation, the beginner not infrequently catches the soft palate and thinking that it is the adenoid mass brings away more or less of this structure. I have seen cases in which three-fourths of the soft palate were thus torn away, and several other cases where perforation of the soft palate resulted. These may all be avoided by not closing the blades until the operator has satisfied himself by digital examination and by turning the handles of the instrument against the upper teeth that he has only the growth between the blades. Sometimes even experienced operators will seize the posterior end of the nasal septum and tear the posterior edge of the vomer. This is not such a serious matter, but may be guarded against as follows: After the forceps are introduced into the naso-pharynx, the blades should be opened and allowed to penetrate the adenoid growth by forcing their ends upward. In this position the handles of the instrument lie against the lower teeth; the instrument is then opened and the blades rotated posteriorly by raising the handles till they rest against the upper teeth. In this rotation the blades pass posterior to the nasal septum and into the mass of adenoids. In this position the blades may be closed. The growth may then be twisted off.

OPERATION WITH THE CURETTE.—The original Gottstein curette, of which there are four sizes, is the best and safest instrument for the beginner. The curette may be used to remove the entire growth, but most often is used as an adjunct to the forceps. The patient is placed in the same position as for the forceps operation. The curette is placed behind the uvula and its handle will lie against the lower teeth. In this position the curette should be pressed upward and backward with a pressure equal to that required to move a weight of about ten pounds. Then with a strong sweep of the curette backward and downward along the dome and posterior wall of the naso-pharynx a large mass of the adenoid tissue will be removed as the curette is withdrawn. Care must be taken that this tissue is not inspired by the patient.

The curette should then be reintroduced and the entire surface of the naso-pharynx repeatedly scraped. The hæmorrhage is sometimes quite marked in this operation, but is easily controlled by a syringeful of hydrogen peroxid and water, equal parts, injected through the nasal cavity.

During operation accidents may arise from difficulty with the anæsthetic, inspiration of tissue and blood, and from hæmorrhage. Complications after operation are hæmorrhage and sepsis. The dangers from the anæsthetic are increased in adenoid cases as these patients take anæsthetics poorly. The mouth should be propped open with a gag to facilitate breathing. The danger of inspiring bits of tissue and blood is considerable, and a tracheotomy tube should always be at hand. Clots and bits of tissue drawn into the bronchi may set up septic inflammation, septic pneumonia, or gangrene of the lung. This may be prevented by allowing the head to hang over the edge of the table, though this position increases the bleeding to such an extent that it is of doubtful use. In case clots of blood are inhaled, it is necessary to stop operating immediately and clear the larynx. This is done by the method known as stripping the

larynx. It consists of grasping the trachea near the sternum between the fingers and pressing upon the trachea by a continuous stripping motion upward so as to force its contents into the larynx. The stripping should be continued upon the larynx when the blood will be forcibly expelled into the mouth. In case this is not immediately successful, the patient should be raised by the heels, the head pendant and jolted, while at the same time an assistant strips the larynx. If this fails, tracheotomy must be performed.

The danger from hæmorrhage is considerable. In all cases where the operation is completely done there must be much loss of blood. The blood is swallowed during operation, even with the head hanging over the table, and patients are apt to vomit quantities of blood. The danger of hæmorrhage immediately after the operation is considerable. If children are left lying upon the back they constantly swallow blood unobserved, until they suddenly develop evidences of acute anæmia and collapse, or else they will vomit unusual quantities of blood. This must be guarded against by laying the child, after operation, upon its face, when any escaping blood from the nose or mouth will make its appearance upon the pillow. When hæmorrhage after operation persists, the nose and pharynx must be filled with hydrogen peroxid solution, which will usually control it. If this is not successful, the naso-pharynx should be plugged.

Dangers after operation are hæmorrhage, sepsis, or tubercular and syphilitic infection. In a few cases death from hæmorrhage has been reported, but such cases were not properly watched, or were of hæmorrhagic diathesis. The methods of avoiding and treating the hæmorrhage have been described above. In addition to those above mentioned, the use of adrenalin chlorid, 1 to 10,000, may be sufficient without the hydrogen peroxid being necessary. In cases of hæmorrhagic diathesis it is sometimes difficult to check the hæmorrhage even with the posterior plug. If the patient has become so exsanguinated as

to produce symptoms of acute anæmia, rectal injections of saline solution may be used and be frequently repeated, and the heart sustained with whisky and strychnine. In a few cases secondary hæmorrhage may come on two or three days after operation. In such cases it is almost always produced by sloughing of the soft parts. This should be regarded as a septic complication.

Sepsis after adenoid operation is of rare occurrence if ordinary care is taken with the sterilization of instruments and operation field. The drainage in this locality is almost perfect. In a few instances there has been sufficient infection to produce some fever and chilly sensations, with soreness of the posterior pharyngeal wall, and occasionally enlargement of the cervical glands. The most serious complication is the extension of sepsis to the Eustachian tube and setting up of middle ear inflammation. All cases of temperature following adenoid operation must not be regarded as septic, since malaria very often affects these patients. In such cases malarial treatment will produce most brilliant results. The diagnosis is made by the temperature curve. Cases where the end of the bony septum has been broken will sometimes be followed by sepsis. This subsides in a few days, without serious consequences.

Cases of tubercular and syphilitic infection have been reported and they occur sufficiently often for the operator to exercise the greatest care as to cleanliness. The following tonsillitis which occurs several days after operation is to be looked upon as septic, and the tonsil should be treated with a strong solution of silver nitrate and the naso-pharynx irrigated with saline solution.

CHAPTER IX.

EXOSTOSES AND SYNECHIÆ.

An outgrowth from the nasal septum, principally composed of bone covered with mucous membrane, appearing along the junction between the upper edge of the vomer and the triangular cartilage in front or between the vomer and the septal plate of the ethmoid behind, is commonly called a spur or exostosis. If formed of cartilage it is called an ecchondrosis. Most of these thickenings, however, are of mixed type, and the term *exostosis* or *spur* should be applied to them all. Another form of thickening sometimes occurs on the surface of the vomer below its edge, and always in the inferior meatus. This form projects as a rounded mass and is something different from the ordinary forms of spur. It is a deposit of true bony tissue in the periosteum, and should be termed a hyper-ostosis, to distinguish it from the ordinary form of spur or exostosis.

The edge of the vomer is inclined obliquely from the end of the nose backward and upward. It follows that if an exostosis is of any considerable length (1 ½ or 2 inches), it must be further from the floor of the nose behind than in front, and the more it is developed posteriorly the higher it is from the floor of the nose. This is a practical point in removing these growths, since the inexperienced operator will often remove them completely in front, but leave them behind.

Very commonly an exostosis accompanies a deflection of the nasal septum. If this is the case, a concavity is seen in the other nostril on the nasal septum, opposite the exostosis. Great care must be taken to differentiate an exostosis from a form of septal deflection in which the thickening occurs on the concave side. (Page 184.)

The length of an exostosis may be measured by means of a probe slightly bent at the end and carried over the top of the exostosis to its most posterior point. It will catch the posterior edge. The length of this from the tip of the nose may then be measured and the probe withdrawn. Then the distance from the anterior end of the exostosis to the tip of the nose is also measured. The difference is the length of the exostosis.

It has been mentioned above that exostoses develop along the articulation of the upper edge of the vomer with the triangular cartilage in front, or of the septal plate of the ethmoid behind. Both the upper edge of the vomer and the under edge of the septal plate of the ethmoid are flanged, and the two when articulated along the flanging edges form a foramen. This foramen contains a projection backward of the triangular cartilage. (See Fig. 57.)

When an exostosis which has developed between the triangular plate of the upper surface of the vomer is removed, the operator in cutting from below upward will cut through the mucous membrane, a thin layer of bone, and then cartilage and mucous membrane. In cutting through an exostosis located over the site of the septal foramen which contains a projection backward from the triangular cartilage, the operator on cutting from below upward will consecutively pass through mucous membrane, the lower flange of bone of the vomer, the projection backward of the triangular cartilage, then the flange of the septal plate of the ethmoid, and lastly, mucous membrane. The cartilaginous part which is often found in the center of an exostosis is therefore this tail-like process of the triangular cartilage.

SPUR OPERATION.

Each side of the nasal septum should be cocainized over the region to be operated upon with a 6 per cent. solution of cocain, containing adrenalin chlorid, 1 to 10,000. After waiting

some five or six minutes a saw may be used to remove the exostosis. This is introduced below the exostosis and saws at first horizontally, parallel with the floor of the nose. The saw is now turned gradually upward, the sawing continued until the exostosis is removed. When the spur comes away, the surface of the septum should be perpendicular.

Difficulty will sometimes be experienced in removing the posterior parts, for the play of the saw is here restricted by the posterior pharyngeal wall. However, with persistence and patience the entire projection may be removed.

HÆMORRHAGE.

There is ordinarily no danger of hæmorrhage from the artery of the nasal septum. It is located below the upper edge of the vomer, and is not cut in the operation. Secondary hæmorrhage frequently occurs, and must be controlled by precisely the same rules which apply to the control of hæmorrhage after deflected septum operations.

AFTER-TREATMENT.

After-treatment consists of surgical cleanliness, the use of aseptic powders or solutions, and the prevention of the formation of exuberant granulations which eventually produce synechia.

SYNECHIA.

Synechiæ are adhesions formed by the production of granulation tissue within the nose.

The granulation tissue may become exuberant, and coming in contact with the opposite side the two surfaces adhere and the granulations organize. As organization continues, contraction occurs, the granulation tissue loses its characteristic form and becomes an organized band or adhesion, forming a bridge across

the nasal space. Such synechiæ persist as organized bands and interfere with respiration and drainage, while at the same time they act as irritable areas, producing all the bad results of contact. Synechiæ are more apt to form in narrow and irritable noses, because there is less space separating the healing edge from the opposite side of the nose; and the parts more readily come in contact in irritable noses. The nasal irritability produces rapid changes in the erectile tissue, which by swelling narrows the lumen of the nostril and brings a moderate quantity of granulation tissue on the septum in contact with the turbinate bodies. If the pressure from the swelling of the turbinate against the growing granulation is constant, it is possible for this pressure to produce an absorption of the epithelial layer on the turbinate opposite the growing granulation tissue, and in this way to start a second growth of granulation tissue opposite the traumatism, which, uniting with the traumatic granulation tissue, will produce a synechia. Carrying this reasoning further, it is possible for synechiæ to form without any injury to the nasal parts, for if two surfaces are constantly in contact their mutual pressure may give rise to a necrosis of the superficial epithelial layer, subsequent formation of granulation tissue, adhesion, and synechia.

The length of a synechia may be measured with a probe. The probe is introduced within the nares at the anterior end of the adhesion, and the measurement taken from the tip of the nose. The bent probe is then passed over the adhesion until the point sinks behind it. The measurement is again taken from this point to the tip of the nose, and the difference in these two measurements will be the length of the synechia.

TREATMENT.

The synechia should be severed with a knife or other cutting instrument and the surfaces kept separated until they heal.

The synechia will form again unless the surfaces are kept separated and unless any slight bony irregularity on the bony septum is smoothed down. Occasionally it may be necessary to amputate a part of the inferior or middle turbinate opposite the synechia, if this turbinate comes in contact either temporarily or permanently with the granulating area.

After the synechiæ have been cut and the rough surfaces smoothed down, a separating plug should be introduced between the cut surfaces. This plug may be of rubber, metal, or cotton. It should be removed every second day, the nostril cleansed, and any exuberant granulation tissue cauterized with silver. The surfaces should then be coated with an antiseptic powder and the separating plug replaced. The plugs should be used until the surfaces no longer come in contact. They may then be tentatively removed, to be reintroduced if any further adhesion takes place.

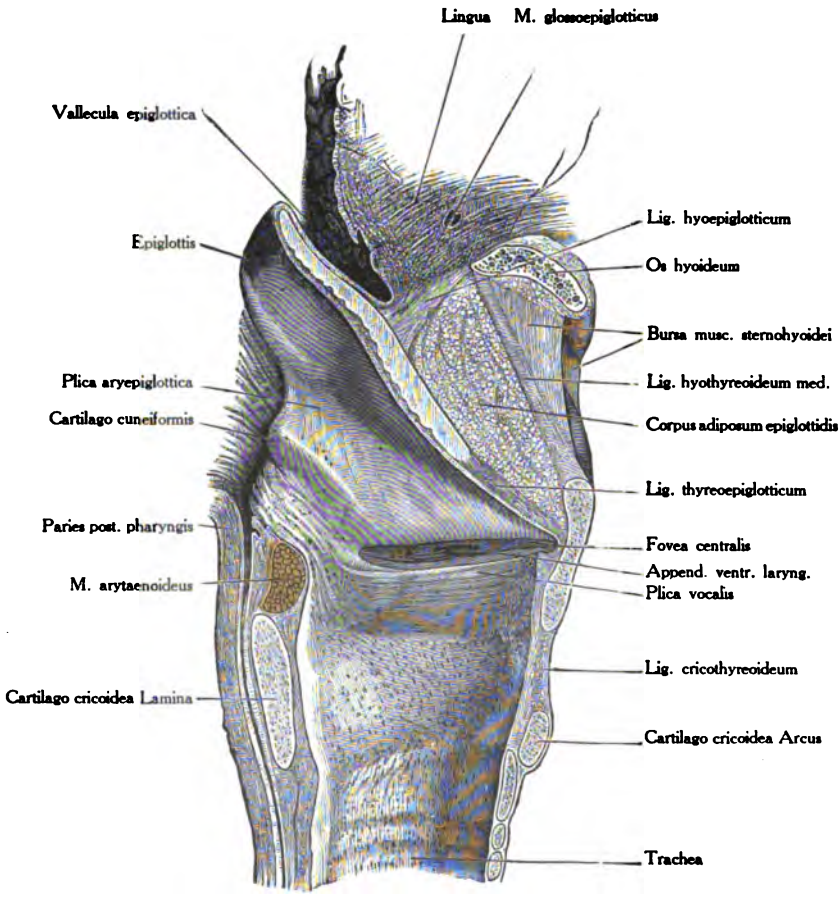


Fig. 74.—Median Section of the Larynx (Zuckerkandl Atlas).

CHAPTER X.

LARYNGOTOMY AND TRACHEOTOMY.

ANATOMY.

THE region which it is necessary to study for the proper understanding of tracheotomy and laryngotomy is strictly confined to the superficial and median part of the neck. It is important for the operator to remember that if he does not deviate from the median line in performing these operations he will deal with very simple structures. They are near the surface and there are but a few simple rules to be remembered.

If the operator deviates much from the median line he is not only outside of the field of operation, but he approaches on each side of the neck, beneath the sterno-mastoid muscles, important relations with the carotids, jugular vein, and pneumo-gastric nerve.

The region, then, that concerns us in this series of operations is bounded above by the chin; below, by the episternal notch; and laterally, by the anterior borders of each sterno-mastoid muscle. Within this region it is easy to distinguish in the median line certain hard and certain soft structures.

HARD STRUCTURES.

The first hard body that can be felt below the chin is the hyoid bone. In the median line it presents a convex surface; it is curved laterally to the sides of the neck where its cornuæ may easily be felt. Between the hyoid bone and the next hard structure below it a space can be felt which is filled by a membrane uniting these two bodies, and known as the thyro-hyoid membrane. Below this, a prominent cartilaginous structure is always discernable. It is the most prominent part of the neck,

and is known as the thyroid cartilage. This body presents two lateral surfaces meeting at an angle in the median line. A prominence on this structure in the median line is known as the Adam's apple or thyroid prominence. This is less prominent in women than in men, for the thyroid cartilages in women are placed at a less acute angle—in fact, the whole larynx is more rounded and less prominent in women than in men.

The third hard structure lies immediately below the thyroid cartilage and is also a part of the larynx. It is known as the cricoid cartilage. It is as easily distinguished as the thyroid cartilage. Its surface is curved, narrow, rounded, and firm. Between the cricoid cartilage and the thyroid cartilage there is another membrane uniting these two bodies, and known as the crico-thyroid membrane.

Immediately below the cricoid cartilage, if the neck is not too fat, the surgeon will feel a soft mass which is the isthmus of the thyroid gland. Between the cricoid cartilage and the isthmus of the thyroid, the first, and sometimes the second, ring of the trachea may be felt. In a few cases several other rings of the trachea may be felt below the isthmus of the thyroid gland, but ordinarily the trachea lies too deep in this region for palpation.

COVERINGS.

All of these parts are covered by skin, superficial fascia, and the platysma myoides muscle. Below the hyoid bone these parts are also in part covered by the sterno-hyoid and the sterno-thyroid muscles, which are separated from the same muscles of the opposite side by a thin white line of fascia. This fascia lies exactly in the median line.

DISSECTION.

In a dissection of this part, the skin, platysma, and superficial fascia should be removed, the sterno-hyoid and sterno-thy-

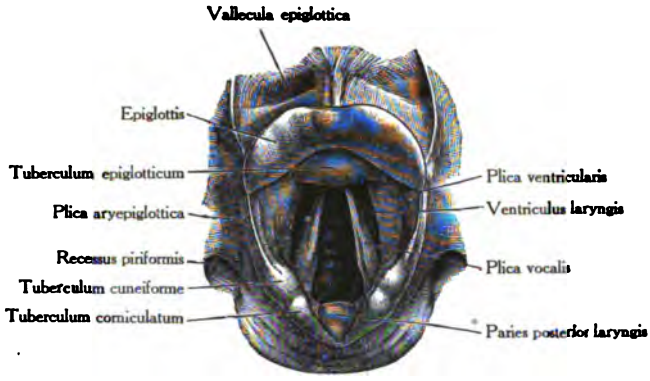


Fig. 75.—View of Larynx Interior (Zuckerkandl Atlas).

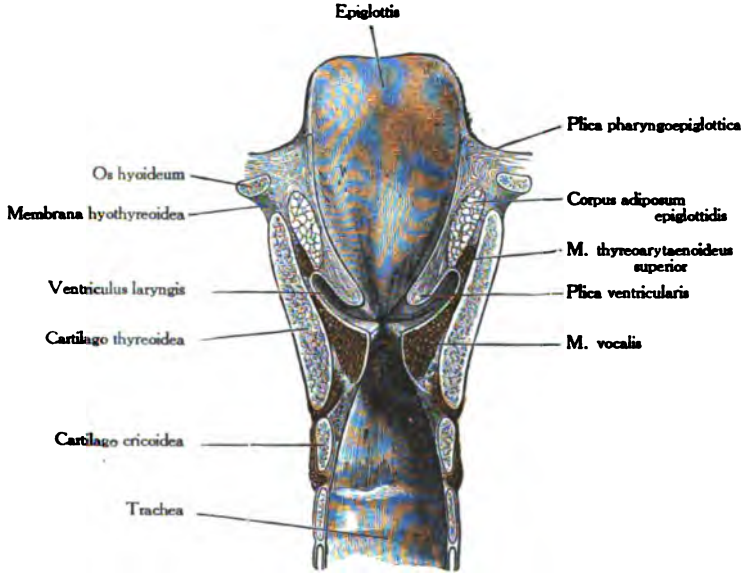


Fig. 76.—Frontal Section Through the Larynx (Anterior Half) (Zuckerkandl Atlas).

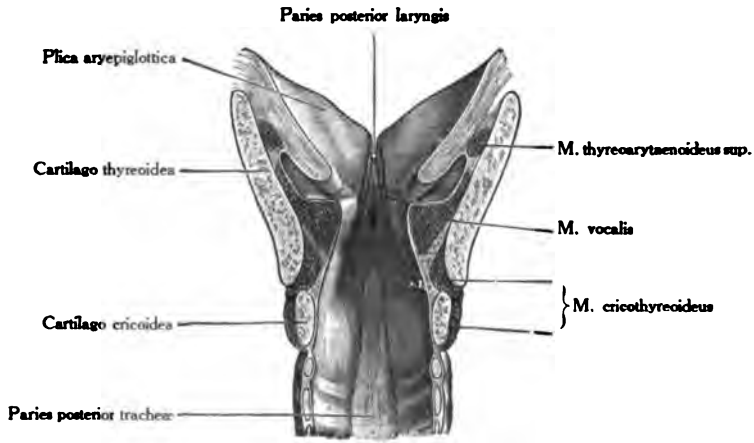


Fig. 77.—Frontal Section Through the Larynx (Posterior Half) (Zuckerkandl Atlas).

roid muscles cut away, and then the parts concerned in these operations may be studied. The thyro-hyoid membrane can be seen uniting the hyoid bone and the thyroid cartilage, the crico-thyroid membrane demonstrated as a very superficial part of the respiratory tract, while below the cricoid cartilage the isthmus of the thyroid gland will be seen crossing the second and third rings of the trachea. Sometimes if the thyroid gland is wide it may extend as far up as the cricoid cartilage and as far down as the third or fourth ring of the trachea. In a few instances a process of the thyroid gland may be seen extending upward in the median line crossing the cricoid cartilage and thyroid cartilage, and sometimes perforating the thyro-hyoid membrane.

Below the isthmus of the thyroid gland the trachea is covered by a plexus of veins which drains the thyroid body and is known as the thyroid plexus. Generally there are two veins on the left and one on the right side, but the arrangement is extremely variable. These veins are often united by anastomosing branches of considerable size which cross the trachea. Still further below, sometimes as high as the seventh ring, the right common carotid artery crosses the trachea, and near it will be found the innominate vein.

Laryngotomy and Emergency Tracheotomy.

There are three laryngotomies—thyro-hyoid laryngotomy, median laryngotomy, and crico-thyroid laryngotomy.

THYRO-HYOID LARYNGOTOMY.

Thyro-hyoid laryngotomy, so-called, is really a pharyngotomy, since the larynx is not opened in this operation. An incision is made in the median line from the chin down to the middle of the thyroid cartilage. The incision is carried through skin, platysma, and the superficial fascia, and between the thyro-hyoid muscles on each side. The thyro-hyoid membrane imme-

diately comes into view, and when the superficial parts are all retracted may be incised from side to side. After cutting through the thyro-hyoid membrane the operator will meet a bolster of fat lying between this membrane and the epiglottis. The anterior surface of the epiglottis now comes into view and should be incised—or, if it is not desirable to remove it, the operator may press it downward into the larynx and have access to the larynx over its upper edge. If the epiglottis is incised, it is generally cut through about its middle. The top of it remains attached by the glosso-epiglottic folds to the tongue, and the base to the larynx. In this way the operator gains entrance to the region at the base of the tongue, the region of the epiglottis, and the entrance to the larynx. Most of the work in this region may be satisfactorily done by endo-laryngeal methods, and this operation is practically obsolete. A preliminary tracheotomy is usually made if it is necesary to remove the base of the tongue. The hyoid bone may be divided by forceps. After the operation the membrane is sutured, then the layer of muscles, and then the skin.

MEDIAN LARYNGOTOMY.

Preliminary tracheotomy is performed. In performing median laryngotomy an incision is made through the skin from the hyoid bone to the trachea. The incision should be made in the median line and will cut through the skin, platysma, and superficial fascia. The white line of separation between the sterno-thyroid and sterno-hyoid on each side will now be seen, and the operator should continue his incision through this line, separating the sterno-thyroid and the sterno-hyoid muscles on each side and retracting them widely. The body of the thyroid cartilage will now lie at the botom of the wound and should be incised exactly in the median line. If any veins interfere, they should be tied and divided. An incision should then be made through the thyroid cartilage exactly in the median line, and, if

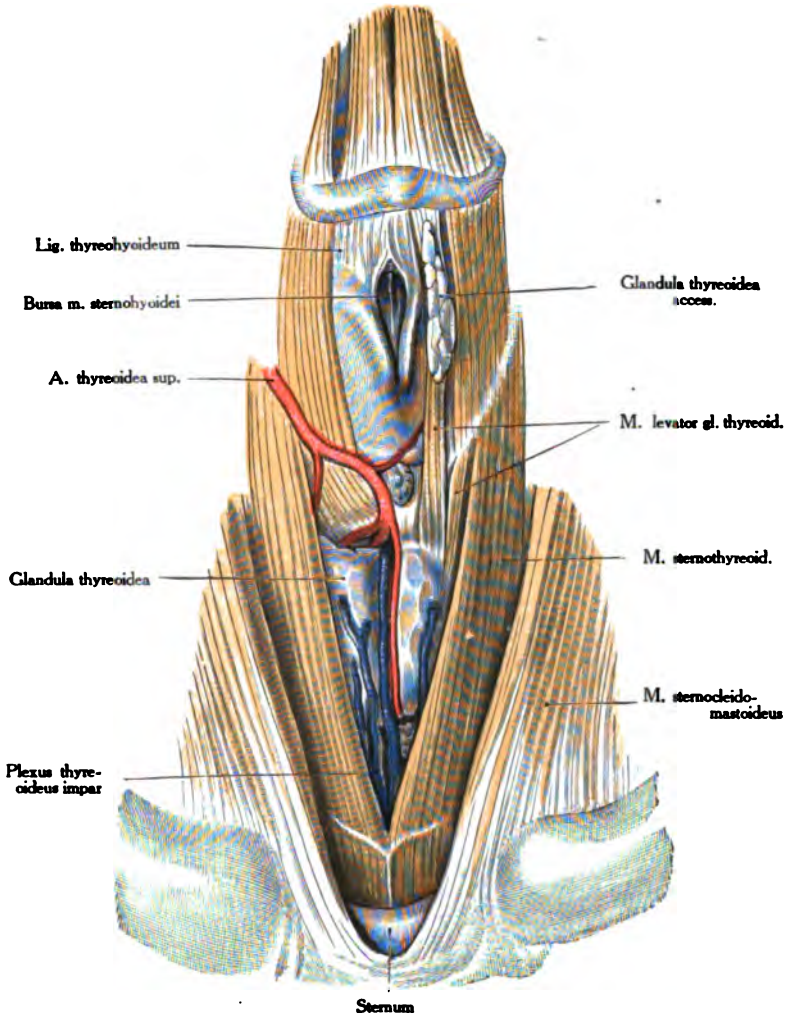


Fig. 78.—Region of Larynx and Trachea (Zuckerkandl Atlas). The sternohyoid muscles are drawn aside. The accessory thyroid gland is shown over the left thyroid cartilage. The superior thyroid artery, the crico-thyroid ligament, and the thyroid plexus of veins are all well shown.

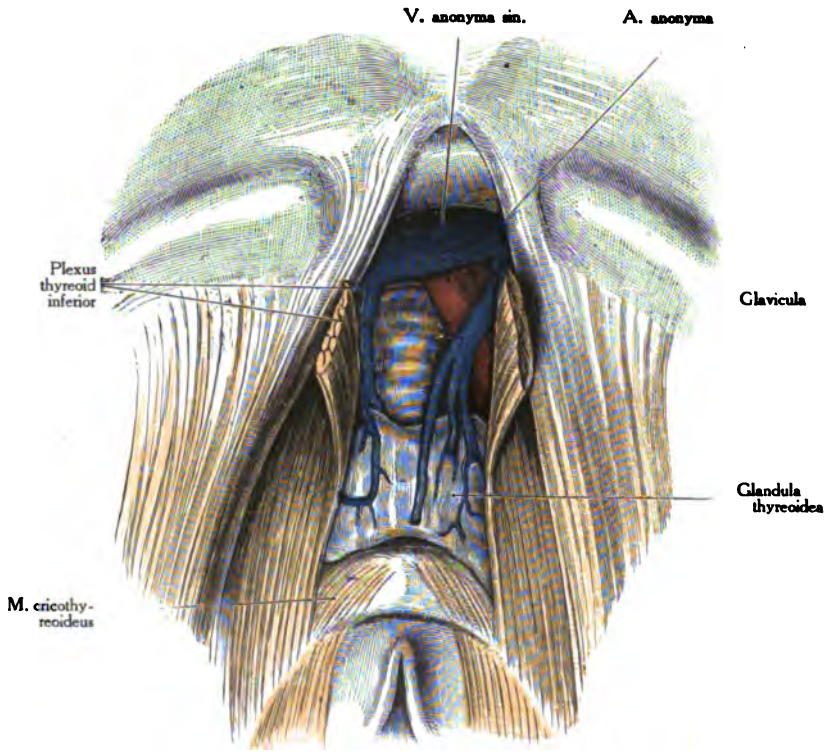


Fig. 79.—Tracheal Region (Zuckerkandl Atlas) viewed from the head. The sternothyroid muscles are cut and drawn aside. The posterior fascia removed. The trachea is bared. In front of the trachea are seen the thyroid veins, emptying into the innominate vein. The innominate artery lies below the vein and crosses the trachea.

necessary, the incision through the air passage may be continued upward through the thyro-hyoid membrane and downward through the crico-thyroid membrane. If this is done, the operator will have an entrance to the respiratory tract extending from the bottom of the hyoid bone to the top of the cricoid cartilage. If care is taken to split the cartilage exactly in the median line, one vocal cord will lie in each lateral half of the larynx. The hæmorrhage which occurs as soon as the larynx is entered should be controlled with cocain and adrenalin chlorid, and the two halves of the larynx separated with retractors. In this way an entrance into the interior of the larynx is gained, and the operator may proceed according to the conditions found present. After the object of the operation has been attained the two halves of the thyroid cartilage are sutured with catgut or silkworm. The muscles and the skin are then sutured and a surgical dressing applied.

CRICO-THYROID LARYNGOTOMY.

This is known as the emergency tracheotomy. It is the seat of election to open an air passage in emergencies, and when operative facilities are very much limited. It is performed in the street with a penknife for an operating instrument, a hairpin for retractor, and a goose-quill toothpick to serve as a respiratory tube. The parts incised are the most superficial of all the parts of the larynx and may be incised with impunity without previous dissection.

In performing this operation the operator feels for the prominent cricoid cartilage and then for the depression between the thyroid cartilage and the cricoid, which indicates the location of the crico-thyroid membrane. These parts are made more prominent by extending the head upon the shoulders, and commonly by bending the head of the patient over the knee of the operator. A knife is then plunged through the skin, fascia, and crico-thyroid membrane, and an immediate entrance is gained

into the larynx. The catheter, quill, toothpick, or rubber tube which is to serve as an emergency tracheotomy tube should now be introduced into the wound and downward into the trachea. This operation is never done except in an emergency, for it is not a satisfactory place for the introduction of a regular tracheotomy tube.

TRACHEOTOMY.

The tracheotomies are:—

1. The supra-thyroid tracheotomy.
2. The infra-thyroid tracheotomy.
3. Low tracheotomy.

Supra-thyroid tracheotomy is performed above the isthmus of the thyroid gland.

Infra-thyroid tracheotomy is performed below the isthmus of the thyroid gland.

Low tracheotomy is performed below the sixth ring of the trachea.

SUPRA-THYROID TRACHEOTOMY.

The skin is incised exactly in the median line, the incision reaching downward 1 ½ inches from the upper border of the cricoid cartilage. The skin, platysma, and superficial fascia are incised and separated by retractors. The operator will now come upon the superficial veins which may require tying and cutting, and will then meet the white line which separates the two sterno-hyoid muscles. The incision should be continued between these muscles and when they are separated with retractors the cricoid cartilage and the upper edge of the isthmus of the thyroid gland will be seen lying at the bottom of the wound. These parts are easily identified—the cricoid by its prominent cartilaginous surface, and the thyroid by its soft yielding consistency and its reddish color. Between these two bodies the first and sometimes the second ring of the trachea may be seen covered with the thyroid

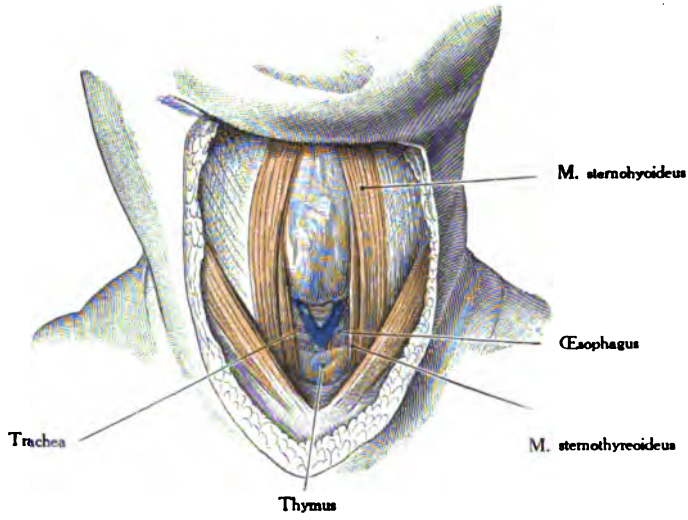


Fig. 80.—Tracheal Region in the New-born (Zuckerkandl Atlas). The fascias are split, the muscles drawn aside. The trachea is seen covered by the thyroid gland, the thymus gland, and the inferior thyroid vein.

fascia. If this fascia is incised and the isthmus of the thyroid gland retracted downward the rings of the trachea will appear at the bottom of the wound. Before the rings of the trachea are incised, all hæmorrhage should be controlled and the wound surface thoroughly dried. If the isthmus of the thyroid gland is bleeding or if it is in the way, it may be tied off by two lateral ligatures passed around it with an aneurism needle and the isthmus incised between the ligatures.

The air tube is now to be opened and the incision should be from the isthmus of the thyroid gland upward toward the cricoid. At least two, and sometimes three rings of the trachea should be incised. As soon as the trachea is opened, a second hæmorrhage is excited from its mucous membrane. This may be controlled by applications of adrenalin chlorid. The cut rings are now retracted and the tracheotomy tube introduced. This is secured with two bands of tape passed around the neck and tied behind, and the surface wound may be partly sutured and partly packed with iodoform gauze. Great care must be taken to keep the tube free, but this is a detail of nursing and need not be considered here.

INFRA-THYROID TRACHEOTOMY.

In this operation the incision is made about one inch from the cricoid cartilage, and extended downward for an inch and a half in the median line. The skin, platysma, and superficial fascia are incised, and the line of the fascia between the thyrohyoid muscles is seen. This line is incised and the muscles separated. In the upper part of the wound the operator will find the isthmus of the thyroid gland, while below this the rings of the trachea will be seen shining through the fascia. Below the isthmus of the thyroid gland one is apt to find dilated veins belonging to the thyroid plexus which bleed freely if incised. They should be ligated and cut. When the fascia covering the trachea is incised and retracted the fourth and fifth rings of the trachea

come into view and after bleeding has been controlled these should be incised, in the median line, from above downward, so as not to wound the isthmus of the thyroid gland. The bleeding from the tracheal mucous membrane is controlled with adrenalin chlorid, and the tracheotomy tube introduced. The wound is then treated as in the previous operation.

LOW TRACHEOTOMY.

This operation which had practically become obsolete is now being revived, especially since the bronchoscope has been introduced by Killian. It furnishes an easy way of introducing the bronchoscope into the right or left bronchus for examination or for the removal of foreign bodies. In performing this operation an incision an inch and a half long is made in the median line upward from the episternal notch. The skin, platysma, and superficial fascia are incised; next the sterno-hyoid and sterno-thyroid muscles are separated from their fellows of the opposite side. The operator now comes upon a number of veins belonging to the thyroid plexus. These should be incised after ligating. The operator next reaches a quantity of fat and a number of lymphatic glands lying in the space over the trachea, and when these have been cut through, the trachea, lying rather deeply, is exposed. Care must be taken not to wound the common carotid artery of the right side, which always crosses the trachea above the episternal notch, and sometimes crosses it abnormally high. When the eighth, ninth, and tenth rings of the trachea have been exposed they are incised from above upward, and the tracheal hæmorrhage is controlled with adrenalin. The bronchoscope or tracheotomy tube is now introduced. After the bronchoscope has been used it is well to introduce a tracheotomy tube to keep the wound open for subsequent investigations, if this should be necessary, but if the result of the operation has been attained the trachea and superficial parts may be sutured and the parts closed by primary union.

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